RAM SBeam™

User Manual

v5.0

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Preface

RAM SBeam is a powerful and versatile program for the design of steel beams. Using one of several design codes, RAM SBeam can select the optimum beam size or check the adequacy of existing construction. The program provides rapid evaluation and comparison between various beams under various load conditions. RAM SBeam has a user interface unparalleled for simplicity and ease of use, while providing a very powerful design capability. This results in substantial time savings for the Engineer and a more economical design for the client.

You should become thoroughly familiar with the documentation and gain a thorough understanding of the program. This will allow you to analyze members more rapidly and correctly.

As a professional, the Engineer is ultimately responsible for the design of the structure. RAM SBeam is a tool to aid in that endeavor; it cannot replace sound engineering judgment.

Features:

- Composite Beam Design and Investigation
- Non-composite Beam Design and Investigation
- Cantilevers
- Braced or Unbraced Compression Flange
- CMC Smartbeams™ Design for both castellated and cellular beams
- ASD, LRFD, Canadian, British or Eurocode design
- English, SI, and Metric Units
- Rolled and Built-up Shapes
- Foreign and Domestic Steel Tables
- Web Opening Design
- Beam Self-weight Automatically Included
- Load Diagrams
- Shear, Moment, and Deflection Diagrams
- User Control of Design Criteria and Parameters

Disclaimer

Table of Contents

Chapter 1

What's New?

An overview of the new features in RAM SBeam v5.0.

1.1 Smartbeams

Smartbeams can now be designed. Select Smartbeam as the material type, specify design information, and perform a member design for both castellated and cellular beams. Review the Fundamentals and Designing Smartbeams sections of the program help to learn more. Additional reference material on Smartbeams has been included in Appendix D.

There are two versions of RAM SBeam. One has all of the capabilities described in this manual, including both Steel beams and Smartbeams. The other is a special CMC Smartbeam version that is only capable of doing Smartbeams; that version will not allow you to select Steel as the material type. That version is available from CMC Steel Products. If you have the CMC Smartbeam-only version and wish to upgrade to the full version, contact Bentley Systems, Inc.

1.2 Composite Ieff

An option to reduce the effective moment of inertia for composite sections by multiplying by 0.75 per AISC 360 Commentary is now available for all AISC codes. This option is selected in the Design Criteria dialog Studs tab.

1.3 Eurocode

The implementation of the Eurocode has been updated from the old pre-standard to the new Eurocode standards, EN 1993-1-1:2005 (Eurocode 4 - Design of Steel Structures) and EN1994-1-1:2004 (Design of Composite Steel and Concrete Structures).

1.4 Launching from RAM Structural System

RAM SBeam can be launched from the RAM Structural System , with geometry, material, loads and design criteria passed from the RAM Structural System to RAM SBeam. This link has been enhanced to include the ability to launch RAM SBeam with CMC Smartbeam data. The link has also been enhanced to include a more complete set of design and criteria information.

Chapter 2

Getting Started

This section includes fundamental concepts and tasks needed to use the program as well as details on the areas of the program window.

2.1 Fundamentals

Explains some of the core concepts and procedures involved in using the program.

2.1.1 What is RAM SBeam?

An introduction to the program.

RAM SBeam is a powerful program for the design of composite or non-composite beams in strict accordance with several steel code design requirements. RAM SBeam allows any combination of point, trapezoidal, and uniform loads, and can be used to select optimum design for new construction or to check adequacy of existing construction. Member sizes and stud information selected by the program can be easily overridden by the user if necessary, and alternate designs can be investigated. The interface provides the designer with a design tool of unmatched ease of use. Data entry is simplified and intuitive, and data can be entered or modified in any order

2.1.2 RAM SBeam Directories

A description of the directories installed with the program.

RAM SBeam will create the following three directories unless they are specified otherwise during installation.

PROG

Contains the executable file `RAMSBeam.exe`, the Help file `RAMSBeam.chm`, and the Manual file `RAMSBeam.pdf`. The default directory is `C:\Program Files\Bentley Engineering\RAMSBEAM\PROG`.

> **Note:** Users of the RAM Structural System or other RAM utility programs may have already established the `PROG` directory on their computer. RAM SBeam can be installed in the `PROG` directory that already exists.

TABLES

Contains the deck and steel beam design tables used by the program. The tables used by RAM SBeam are the same tables used by the RAM Structural System. The default directory is `C:\Program Files\Bentley Engineering\RAMSBEAM\TABLES`.

DATA

Contains the output data files of individual beam runs created when the Save command is invoked. The default directory `C:\Program Files\Bentley Engineering\RAMSBEAM\DATA`.

2.1.3 Documentation Conventions Used

The following typographical and symbolic conventions are used throughout this reference:

Typograhpical Conventions

`File Path/File Name.extension`

A fixed width typeface is used to indicate file names, file paths, and file extensions (e.g., `C:/Program Files/Bentley/…/Prog/RAMSBeam.exe`)

Interface Control

A bold typeface is used to indicate user controls. Menu and sub-menu items are indicated with a series of > characters to distinguish menu levels. Windows shortcut keys are underlined. (e.g., **File** > **Save As…**).

User Input

A fixed width typeface is used to indicate information which must be manually entered.

Notes, Tips, and Warnings

Items special note are indicated as follows:

> **Note:** This is an item of general importance.

> **Tip:** This is optional time-saving information.

> **Warning:** This contains information about actions that should not be performed under normal operating conditions.

Mathematical Notation

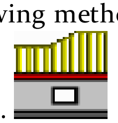
Similar to spelling conventions, American mathematical notation is used throughout the documentation. A serif typeface is typically used to clarify numbers or letters which might otherwise appear similar.

- Numbers greater than 999 are written using a comma (,) to separate every three digits. For example, the U.S. value of Young's Modulus is taken as 29,000,000 psi.
- Numbers with decimal fractions are written with a period to separate whole and fraction parts. For example, a beam with a length of 21.75 feet.
- Multiplication is represented with a raised, or middle, dot ( ). For example, P = F A.

2.1.4 Starting RAM SBeam

Used to initiate the program.

1. RAM SBeam can be started by any one of the following methods:

   In the Program Group, select the RAM SBeam icon. 
   or
   in Windows Explorer, double-click a RAM SBeam file (with the file extension `.rsb`).
   or
   in Windows Explorer, double-click the icon for the file `RAMSBeam.exe`.
   The RAM SBeam program window opens.

2.1.5 Specify Job Information

Enter job information which will be displayed on screen and used in report headers.

1. Select **File** > **Job Information...**
   The Job Information dialog opens.
2. Specify a **Job Name** and/or **Comments** describing the SBeam job.
3. Select the option to **Show this dialog when Print is issued** to re-open this dialog when printing.
4. Click **OK**.
   The dialog closes and the Job Information is saved to the current SBeam file.

2.1.6 Select beam material type

The material selection box displays the currently selected material (steel or Smartbeam). Use the following procedure to switch the material type.

> **Note:** In the CMC version, only the Smartbeam material is available.

1. Click the drop-down arrow in the material selection box .
2. Select either Steel or Smartbeam for the material.
   The beam diagram in the View window updates. Material-specific controls for the selected material become active.

2.1.7 Changing the Unit System

RAM SBeam can accept input and provide output in English (US Imperial), SI or Metric units.

The capability to change units at any time is useful in the case where a job requires the production of designs in units in which you are unaccustomed to working. A beam can be modeled and designed in a familiar system of units. Once the design is completed to your satisfaction, the units can be changed for the final output reports.

1. Select **Criteria** > **General**.
   The General Criteria dialog opens.
2. Select the **Units** tab.
   The General Criteria dialog Units tab is displayed.
3. Select the input and output unit system you wish to use.
4. Set the **Save as Default** option to use this as the default unit system.
5. Click **OK**.
   The dialog closes and the values of all input are updated to display in the selected system of units.

2.1.8 Changing Criteria and Property Defaults

The default criteria and property values can be customized.

Initial Default Criteria are set during the installation process. You can modify any default values at any time. Use the following procedure to modify a default value:

1. Select the Criteria menu item containing the default to be changed.
   The corresponding dialog opens.
2. Specify one or more new default value(s).
3. Set the **Save as Default** option.
4. Click **OK**.
   The dialog closes and the specified value(s) are set as the default.

Some material property items can likewise be set as defaults in the Span Definition dialog and the Composite dialog .

The specified values will now be the default values whenever the program is run.

Tip: It is recommended that all of the defaults be thus specified and modified immediately after installing the program, if necessary, prior to proceeding with any designs. Care should be taken to specify all criteria on all tabs of all of the commands, and it should be done in the order that the commands appear in the menus in the program.

2.1.9 Exiting RAM SBeam

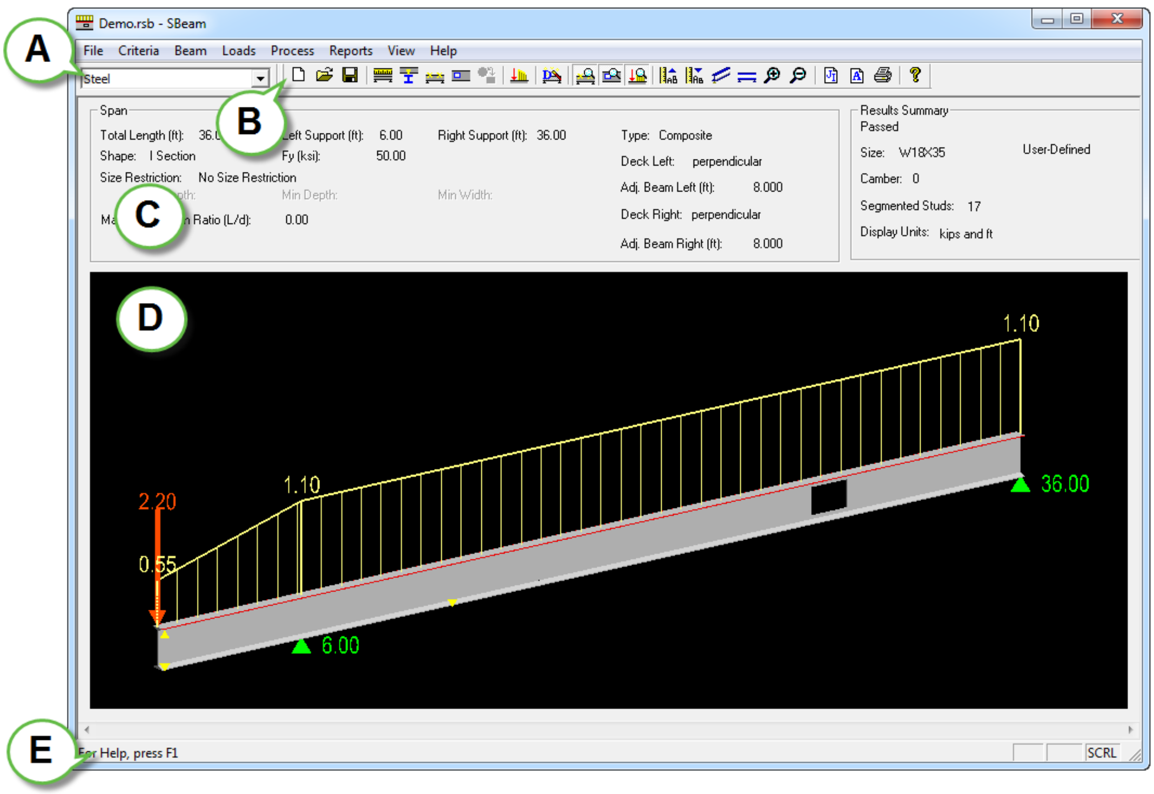
Exit the program when your are finished with beam designs.

1. You may exit the program by a number of methods:
   Select **File** > **Exit**.
   or
   Click the program close icon in the top-right corner of the program window. 
   or
   Press ALT+F4.
   The program window closes.

2.2 Application Window Layout

The application window contains these sections by default.

Figure 2-1: Sections of the program window



Refer to the Menus section for a description of the Menu bar items.

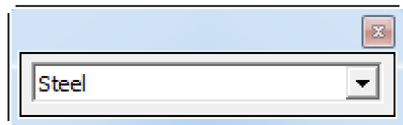
2.2.1 Material Selection

Used to select the beam material type.

When designing a beam, you will use the drop-down menu to select a material type. In RAM SBeam, the available materials are either Steel or Smartbeam.

> **Tip:** The selector is located at the top, left-hand corner of the program window, just below the File menu.

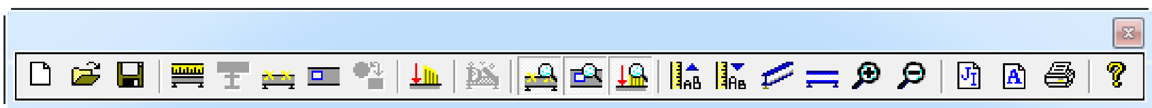
Figure 2-2: The material selector



2.2.2 Toolbar

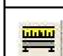
The Primary Tools toolbox is a launch point for commonly used tools.

Figure 2-3: The main toolbar



> **Tip:** The display of the toolbar can be toggled by selecting **View** > **Toolbar**.

Table 2-1: Toolbar items

Icon	Description	Same Effect as Selecting...
 New	Used to clear all current data and open an empty file with the default criteria and properties.	**File** > **New**
 Open	Used to open a file that was previously saved by RAM SBeam.	**File** > **Open**
 Save	Used to save all of the current criteria settings, beam geometry, loads, etc. If the beam size has been specified as a user-specified size (rather than as an optimum size), the size and studs will be saved as well.	**File** > **Save**
 Span Info	Opens the Span Definition dialog , which is used to define span lengths and general beam properties.	**Beam** > **Span Definition...**

Icon	Description	Same Effect as Selecting...
 Composite Info	Opens the Composite dialog , which is used to edit composite deck and rib spacing details.	**Beam >** **Composite...**
 Define Bracing	Opens Bracing dialog , which is used to define discrete top or bottom flange braces as well as unbraced top flange segments.	**Beam >** **Bracing...**
 Define Openings	Opens the Layout Web Openings dialog , which is used to add or edit beam web openings.	**Beam > Web** **Opening...**
 Duct Size...	Opens Duct Size dialog , which is used to specify duct size and shape to be considered for the design of Smartbeams.	**Beam > Duct** **Size...**
 Define Loads	Opens the Load Cases dialog , which is used to view and/or change loads on the beam.	**Loads > Load** **Cases...**
 Design Beam	Designs the beam and opens either the View/Update Beam dialog or the Smartbeam View Update dialog .	**Process >** **Beam** **Design...**
 Show Brace Points	Toggles the display of flange braces in the graphical display.	**View > Brace** **Points**
 Show Web Openings	Used to toggle the display of the web openings and stiffeners on the beam.	**View > Web** **Openings**
 Scale Text Up	Increases the size of text in the View window.	

Icon	Description	Same Effect as Selecting...
 Scale Text Down	Decreases the size of the text in the View window.	
 Perspective View	Orients the beam in the View window to a perspective view.	**View** > **Rotate to Perspective**
 View Profile	Orients the beam in the View window to a profile view.	**View** > **Rotate to Profile**
 Zoom In	Used to increase the View window's magnification.	**View** > **Zoom In**
 Zoom Out	Used to decrease the View window's magnification.	**View** > **Zoom Out**
 Set Job Name	Opens the Job Information dialog , which is used to specify optional descriptive information on the project which is then included in report headers.	**File** > **Job Information**
 Report Preferences	Opens the Report Preferences dialog , which is used to change report options, including text styles for various parts of the report.	**Reports** > **Report Preferences...**
 Print Screen	Prints the contents of the View window.	**File** > **Print Screen...**
 About	Opens the About RAM SBeam dialog, which contains version and copyright information.	**Help** > **About RAM SBeam...**

2.2.3 Properties Panel

Displays a summary of the beam input and design results.

2.2.4 View window

Displays a graphical representation of the beam, loads, openings, and conditions.

Use controls located in the View menu or on the Toolbar to manipulate the View window.

2.2.5 Status Bar

Displays tips for using the window tool over which the mouse pointer hovers.

Note: The display of the Status Bar can be toggled by selecting **View** > **Status Bar**.

2.2.6 Report Viewer window

Used to display reports on screen.

Table 2-2: Report Viewer window controls

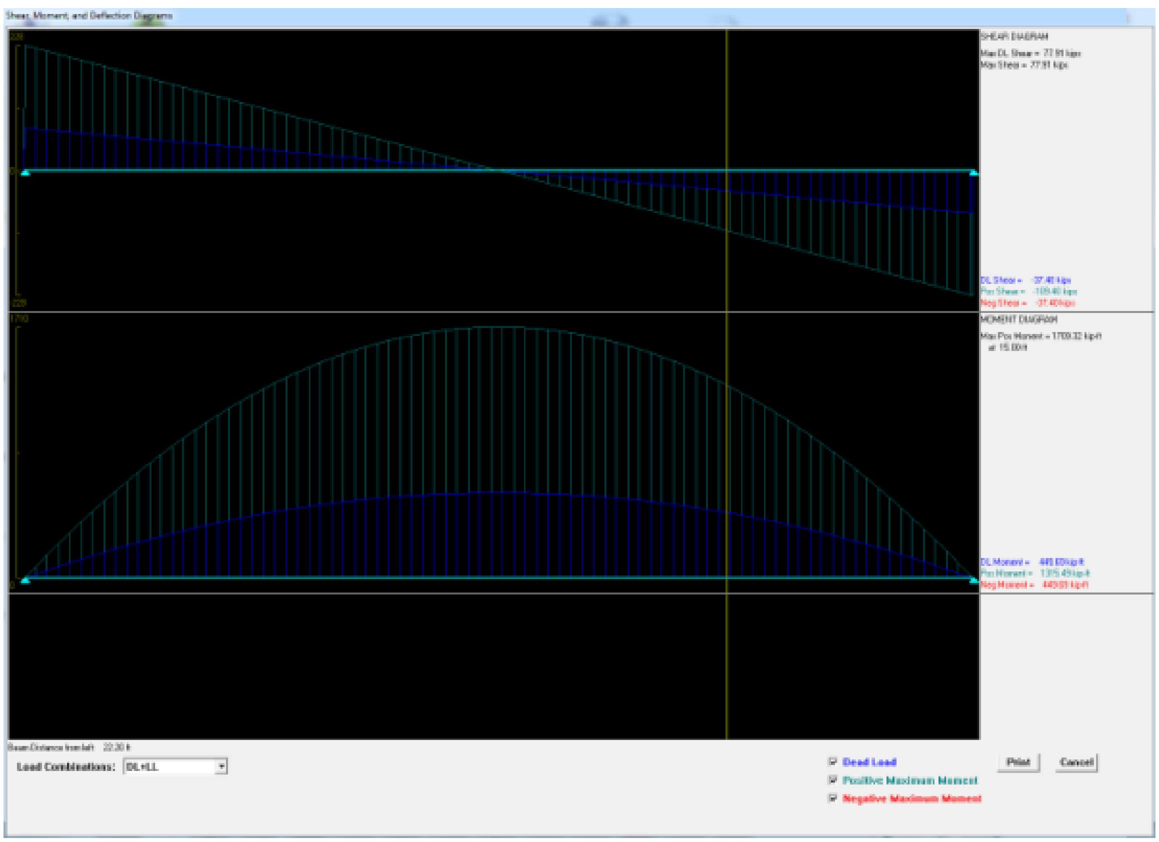
Tool	Description	Shortcut
Print the Document	Opens a Print dialog, which is used to print the current report.	
Set Scale 1:1	Displays the report at the default magnification.	
Show Full Page	Displays the entire report at lowest magnification.	
Zoom In	Increases the magnification.	Insert or Left-click
Zoom Out	Decreases the magnification.	Delete or Right-click
Go to First Page	Displays the first page of the report.	CTRL+Page Up
Go to Previous Page	Displays the previous page of the report.	Page Up
Go to Next Page	Displays the next page of the report.	Page Down

Tool	Description	Shortcut
Go to Last Page	Display the last page of the report.	CTRL+Page Down
Help on Control	Opens the Usage dialog, which contains shortcuts for controlling the report display.	
Close Preview	Closes the Report Viewer window.	ALT+F4

2.2.7 Shear, Moment, and Deflection Diagrams window

Used to review the shear, bending, and deflection diagrams for the current beam design. Opens when the **View Diagrams** button is clicked on the View/Update Beam dialog.

Figure 2-4: The Shear, Moment, and Deflection Diagrams window



Window Controls

diagrams

The diagrams are shown using the selected loads. A vertical, yellow line is used to indicate the mouse position along the length of the beam with the values of shear,

moments, and deflection being reported at the point to the right side of the respective diagram.

Load Combination
: Select the load combination to display from the drop-down list. Considered combinations of load specified in the Loads dialog are listed.

load options
: Select the load types or load effects to display. Load types are color coded with the values at the selected location in the diagram legends. Click the checkbox to remove the load effect from the diagrams.

Print
: Opens a Print dialog, which is used to select a printer to which you wish to send the diagram output.

Cancel
: Closes the window.

Chapter 3
Designing Steel Beams

This section details how to evaluate or optimize composite and non-composite steel beams.

3.1 Define the Beam Span

Set the span length, select a material, define composite and bracing action, and specify design limits.

1. Select either
   Beam > Span Definition...
   or
   the **Span Definition** tool found on the toolbar . 
   The Span Definition dialog opens.
2. Specify the length of each span.
   If one or both cantilevers are not present, simply leave this value as 0.00.
3. Select a class of beam cross sections to use as the **Shape**.
4. Specify a yield strength, **Fy**, appropriate for the selected **Shape**.
5. Set the **Type** option (i.e., the composite flag) which describes the floor or deck conditions.
6. Specify a **Span/Depth Limit** if necessary.
   A higher value will result in a more shallow cross section. Leave the value as zero (0.0) to have the program ignore the L/d limit.
7. Specify one or more size restrictions if necessary.
   You can limit the size of the resulting design using a range of values here.
8. Set the **Save As Default** option to use these settings for future beam designs.

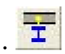
3.2 Define the composite floor system

For composite beams, add the required deck and concrete parameters.

Prior to defining a composite floor, the span must be defined.

This set of steps is not required for beams which have been flagged as non-composite in the Span Definition dialog .

1. Select either
   Beam > Composite...
   or

   the **Composite Info** tool found on the toolbar . 
   The Composite dialog Decking tab opens.
2. Specify the **Distance to adjacent** beams or slab edges in the Deck Span parameters.
3. Specify the ultimate strength, **Fu**, **Diameter**, and **Length** for the Studs.
   The default ultimate strength and diameter may be used but the length value must also be provided.
4. Set the **Beam is Shored** option, if the beam is to be shored.
5. Specify the Deck and Fill parameters in the table for both left and right sides of the beam.
6. Select the options to **Save Stud Fu and Stud Diameter as Default**and/or **Save Conc f'c and Conc Unit Weight as Default**to use changed values in the future.
7. Select the Ignore Rib Spacing tab and select the option to **Ignore Rib Spacing When Determining Stud Spacing** if this is required.
   Be sure to select the appropriate condition for the ribs over the beam top flange.
8. Click **OK** to save the composite parameters and close the dialog.

Once the floor system has been defined for a composite beam, you may proceed to define flange bracing or add web openings if necessary or add loads to the beam .

3.3 Define flange bracing

Used as needed to specify brace points along the top or bottom flange as well as unbraced segments for otherwise braced top flanges.

Prior to defining bracing points, the span must be defined and, for composite beams, the floor deck information must be provided .

Bracing points which coincide with concentrated loads (e.g., supporting a secondary beam framing from either side) can be specified in the Loads dialog Concentrated Loads tab .

1. Select either
   Beam > Bracing...
   or

   the **Define Bracing** tool found on the toolbar . 
   The Bracing dialog opens.
2. Specify the distance to any top and/or bottom flange brace points and select which flanges are being braced at this point.
3. (For composite beams only) Specify any unbraced segments by adding a beginning point and end point, as measured from the left end of the beam.

4. Click **OK**.
   The dialog closes and the specified beam bracing is displayed on the beam in the View window. Yellow pointers are used on flanges to indicate brace points. Top flange braced segments are indicated with a red line along the flange tip.

3.4 Add web openings

Used to add rectangular or round web openings in the beam.

Prior to adding web openings, the span must be defined and, for composite beams, the floor deck information must be provided.

Opening can be added or changed in this dialog. Previously defined openings can be modified using the Modify Web Opening dialog.

1. Select either
   Beam > Web Openings...
   or
   the **Define Openings** tool found on the toolbar. 
   The Layout Web Openings dialog opens.
2. Specify Location information to the center of the opening along the length of the beam.
3. Specify the vertical position of the opening along the depth of the web.
4. Select either the **Rectangular** or **Circular** option for the opening shape and specify the dimensions of the opening.
5. Click the **Add** button.
   The opening information is added to the Web Opening Data table.
6. Repeat steps 2 through 5 to add as many openings as necessary.
7. Click **OK**.
   The dialog closes. The web opening data is saved.

3.5 Apply loads to the beam

Used to add net loads to the beam.

Prior to adding loads, the span must be defined and, for composite beams, the floor deck information must be provided.

Loads are composed of Dead Load, Construction Dead Load, Live Load, and Construction Load.

After the loads have been specified they are displayed in the View window as applied on the beam. The total load values (Dead plus Live) are shown.

3.5.1 Add a uniform load

Add a load of uniform force per unit length along the entire beam (cantilevers and main span).

1. Either select
   Loads > Load Cases...
   or
   the **Define Load** tool.
   The Loads dialog Uniform Load tab opens.
2. Specify values for any combination of **Dead Load**, **Construction Dead Load**, **Live Load**, and **Construction Live Load**.
3. Select the option to **Consider Beam Self-Weight** to superimpose the weight of the steel beam in addition to the specified uniform Dead Load.
4. Add loads from other tabs if necessary.
5. Click **OK**.
   The load data is saves and the dialog closes.

3.5.2 Add a partial uniform load

Add a load of uniform force per unit length over a portion beam.

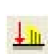
1. Either select
   Loads > Load Cases...
   or
   the **Define Load** tool.
   The Loads dialog opens.
2. Select the Partial Uniform Load tab.
3. Specify values for any combination of **Dead Load**, **Construction Dead Load**, **Live Load**, and **Construction Live Load** in a row within the table.
4. Specify a Start and End distance for the uniform load.

   > **Tip:** Load distances are measured from the far, left end (including cantilever length). Distances to span ends are shown at supports in the View window.

5. Repeat steps 3 and 4 to add more partial uniform loads.
6. Add loads from other tabs if necessary.
7. Click **OK**.
   The load data is saves and the dialog closes.

3.5.3 Add a trapezoidal load

Add a load of varying force per unit length over a portion of the beam.

1. Either select
   Loads > Load Cases...
   or
   the **Define Load** tool.
   The Loads dialog opens.
2. Select the Trapezoidal Load tab.
3. Specify values for any combination of **Dead Load**, **Construction Dead Load**, **Live Load**, and **Construction Live Load** at both the Left and Right ends of the load in a row within the table.

4. Specify a **Distance** to the Left and Right end.

> **Tip:** Load distances are measured from the far, left end (including cantilever length). Distances to span ends are shown at supports in the View window.

5. Repeat steps 3 and 4 to add more trapezoidal loads.
6. Add loads from other tabs if necessary.
7. Click **OK**.
   The load data is saves and the dialog closes.

3.5.4 Add a concentrated load

Add a load of uniform force per unit length over a portion beam.

1. Either select
   Loads > Load Cases...
   or
   the **Define Load** tool.
   The Loads dialog opens.
2. Select the Concentrated Load tab .
3. Specify values for any combination of **Dead Load**, **Construction Dead Load**, **Live Load**, and **Construction Live Load** in a row within the table.
4. Specify a Start and End distance for the uniform load.

> **Tip:** Load distances are measured from the far, left end (including cantilever length). Distances to span ends are shown at supports in the View window.

5. Repeat steps 3 and 4 to add more concentrated loads.
6. Add loads from other tabs if necessary.
7. Click **OK**.
   The load data is saves and the dialog closes.

3.6 Perform the beam design

Perform an analysis and design of the steel beam.

As a minimum, the span and loads must be defined prior to performing the design. For beams flagged as composite, the composite floor system must also be defined.

1. Select one of the following to initiate the beam design:
   Process > Beam Design...
   or
   the **Design Beam** tool.
   The design is performed. Any errors are displayed in warning dialogs. The View/Update Beam dialog opens.

3.6.1 To try a different beam size

Use the following procedure to try a beam size other than the optimized selected by the program.

1. Open the View/Update dialog .
2. Select the desired size in the **Beam Size** list.
3. Click the **Analyze** button.
   RAM SBeam performs a beam analysis. Warning dialogs will present any issues with the selected beam design.
4. Click the **Save Design** button to save the selected beam design.

3.6.2 To try a different yield strength

Use the following procedure to try a different material grade.

1. Open the View/Update dialog .
2. Enter a new value for the yield strength in the **Fy** field.
3. Click the **Optimize** button.
   A new beam size is selected by the program.
4. Click the **Save Design** button to save the selected beam design.

3.6.3 To change composite setting

Use the following procedure to edit the composite flag.

1. Open the View/Update dialog .
2. Select either the Composite or Noncomposite option for the Composite flag.
3. If the composite flag has been set to Composite, then you may also update the Stud Configuration.
4. Click the **Optimize** button.
   A new beam size is selected by the program.
5. Click the **Save Design** button to save the selected beam design.

3.6.4 To modify web openings

Use the following procedure to modify the geometry and design of web openings.

Only existing openings can be modified using this procedure. To add or delete an opening, use the Layout Web Openings dialog .

1. Open the View/Update dialog .
2. Click the **Modify**>> button.
   The Modify Web Opening dialog opens, displaying the opening and stiffener data which can be modified as desired.
3. Select from the Opening Data table the opening to be modified.
4. Modify any values or options.
5. Click the **Change** button.
6. Repeat steps 3 through 5 for each opening for which modifications are desired.

7. Click **OK**.
   The dialog closes.
8. In the View/Update dialog, click the **Analyze** button.
   The beam is analyzed for changes made in both the View/Update and Modify Web Opening dialogs. The Pass/Fail status of the web-opening and/or stiffener design is displayed in the Web Opening Data table.

Chapter 4

Designing CMC Smartbeams™

This section details how to evaluate or optimize castellated or cellular Smartbeams.

Smartbeam™ is a proprietary product of CMC Steel Products (formerly known as SMI Steel Products). It comes in two varieties: Castellated (with hexagonal web openings) and Cellular (with round web openings). Smartbeam design has been implemented in the RAM SBeam. A Smartbeam is created from a standard wide-flange beam by cutting it longitudinally in a zig-zag or semi-circular pattern, separating and offsetting the two halves, and welding them back together. The result is a deeper, stiffer beam of the same weight as the original. Also, the resulting holes in the webs permit mechanical ducts, plumbing, and electrical lines to pass through the beam rather than beneath the beam. Smartbeams may be designed as either composite or noncomposite beams.

Note: The procedures which are different from steel beams or unique to Smartbeams are detailed within this section. Many of the steps involved in the design of Smartbeams are the same as how you design a steel beam.

4.1 Define Smartbeam Criteria

Specify the opening value increments and method of deflection calculation to use in design.

1. Select **Criteria** > **Smartbeams...**
   The Smartbeams dialog opens.
2. Specify dimension increment values to be used in Castellated and/or Cellular beam design.
3. Select the method to use for calculation of **Noncomposite Deflection**.

4. Select to **Save As Default** to use these settings for future Smartbeam designs.

   Tip: This can save you the effort of repeating these steps for each design.

5. Click **OK**.
   The dialog closes and your changes are saved.

4.2 Define the Beam Span

Set the span length, select a material, define composite and bracing action, and specify design limits.

1. Select either
   Beam > Span Definition...
   or

   the **Span Definition** tool found on the toolbar . 
   The Span Definition dialog opens.
2. Specify the span length.
3. Select a either a **Castellated** or **Cellular** Smartbeam.
4. Specify a yield strength, **Fy**.

   Warning: Consult with CMC before specifying any value other than 50 ksi.

5. Set the **Type** option (i.e., the composite flag) which describes the floor or deck conditions.
6. Specify a **Span/Depth Limit** if necessary.
   A higher value will result in a more shallow cross section. Leave the value as zero (0.0) to have the program ignore the L/d limit.
7. Specify the **Connection Type** at each end of the beam.
8. Specify one or more size restrictions if necessary.
   You can limit the size of the design results using a range of values here.
9. Set the **Save As Default** option to use these settings for future beam designs.

For Smartbeams with composite type floors, the composite floor system must be defined. This procedure is the same as for steel beams .

4.3 Specify a duct size

Used to specify the size of mechanical ducts that the web openings in the Smartbeam must accommodate.

Prior to specifying a duct size, the span must be defined and, for composite Smartbeams, the floor deck information must be provided.

1. Select either
   Beam > Duct Size...
   or

   the **Duct Size** tool. 

The Duct Size dialog opens.

2. If a duct is to be specified, select either the **Rectangular** or **Round** option and specify dimensions.
   If you are clearing a previous duct size definition, select the **No Duct Specified** option.
3. Set the **Save As Default** option if this duct size is to be used for future designs.
4. Click **OK**.
   The dialog closes. The duct size information is saved and is displayed in the Properties Panel.

4.4 Perform the Smartbeam design

Perform an analysis and design of the Smartbeam.

As a minimum, the span and loads must be defined prior to performing the design. For Smartbeams flagged as composite, the composite floor system must also be defined.

1. Select one of the following to initiate the beam design:
   Process > Beam Design...
   or
   the **Design Beam** tool.
   The design is performed. Any errors are displayed in warning dialogs. The Smartbeam View Update dialog opens.

4.4.1 To infill a web opening

Used to fill a web opening in a Smartbeam where necessary (e.g., a transfer column).

The ability to infill openings can only be performed on beams with a specific DT, e and phi in the case of Castellated beams and Do and S in the case of Cellular beams.

Note: Distance **e** or **S** is specific if the minimum and maximum values assigned to the range are the same. To infill an opening, double-click the opening in the graphic at the bottom of the View/Update dialog box or double-click an opening location in the Openings Data list. To remove infills, double-click the infill in the graphic or opening location in the Openings Data list.

1. Open the View/Update dialog.
2. Deselect the **Optimize** checkbox for
   Dt and **e min/max**, in the case of a castellated beam
   or
   Diameterand **S min/max**, in the case of a cellular beam.
   You are now able to specify a these values directly rather than use the program optimized values or ranges.
3. Enter the same value in the
   e min/max, in the case of a castellated beam
   or
   S min/max, in the case of a cellular beam.

4. For castellated beams, set the **Use** option for phi. Specify a value for **Top Tee phi** or **Bottom Tee phi** as needed.
5. Click either
   the **Analyze** button, to analyze the current beam size for the other specified data
   or
   the **Optimize** button, to have the program select an optimum beam size for the specified data.
   The program reports results of the procedure.
6. To mark an opening as infilled, either
   double click the Opening Data table row for the opening
   or
   double click the opening in the beam elevation diagram.
   The Infill column in the Opening Data table row is marked Yes and the opening is shaded in the diagram. Repeat this step for other openings as needed.
7. Click the **Analyze** button.
   The results are updated with an analysis accounting for infilled openings.

Chapter 5

Output and Creating Reports

RAM SBeam output is designed to provide the engineer with all the necessary data for review of, and calculation submission for, a beam design.

Except for the calculation of loads, the need for hand calculations is virtually eliminated for most beam designs.

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5.1 Generating a Design Report

Used to output a report for the current beam design.

1. Perform a successful beam design.
   Reports are not available until the beam has been designed.
2. Select the desired output destination (Screen, Printer, Text File, or Viewer File) from the Reports menu.
   A check mark is displayed next to the current report destination.
3. Select **Reports** > **Beam Design**.

   > **Note:** If the **Show this dialog when Print is issued** option was selected in the Job Information dialog , the Job Information dialog opens allowing you to edit the Header information for the report.

4. Make any desired changes to the Job Information.
5. Click **OK**.
   If Screen is the selected destination, the Report opens in the Report Viewer window. If Printer is the selected destination, a Print dialog opens to generate a hard copy of the

design report. Otherwise, a Save As dialog opens prompting you to select a file name and location for the selected file type.

5.2 Print a copy of the shear, moment, and deflection diagrams

Create a hard copy of the beam shear, bending, and deflection diagrams.

The span definition and load information must be specified in order to view the diagrams. Composite floor data must also be specified for composite beams.

1. Select one of the following to initiate the beam design:
   Process > Beam Design...
   or
   the **Design Beam** tool.
   The design is performed or, for a frozen design, the be is analyzed. For steel beams, the View/Update Beam dialog opens and for Smartbeams, the Smartbeam View Update dialog opens.
2. Click the **View Diagrams** button.
   The Shear, Moment, and Deflection Diagrams window opens.
3. Select the desired **Load Combination**.
   The diagrams update to reflect the selection.
4. Select the load effects you wish to display.
   The diagrams update to reflect the selection.
5. Click the **Print** button.
   A Windows Print dialog opens.
6. Select the printer and printer settings you wish to use.
7. Click the **Print** button.
   The dialog closes. Focus returns to the Shear, Moment, and Deflection Diagrams window.
8. Click the **Cancel** button.
   The window closes. Focus returns to the View Update dialog for the current material.

5.3 Beam Design Output

The following is a brief description of the output provided by RAM SBeam for steel beam designs.

Note: Output in English (US Imperial), SI or metric units can be obtained by setting the model units on the General Criteria dialog Units tab .

5.3.1 Allowable Stress Design AISC ASD 9th

This output contains a complete description of individual beam designs. Beam size, span length, yield strength, composite properties, loading patterns, moments, reactions and deflections are all included in this output.

Page Heading

The heading lists the current version of RAM SBeam, the Job Name and Description if specified by the user, the licensee Company name, and the date and time that the report was generated.

Steel Code

Steel Code
The steel design code selected and used in the design of the beam.

Span Information

Depth or Width Limitation Specified
If any beam depth or width limitations have been specified, they will be listed.

Beam Size
Designed beam size. It is either the optimum size selected by the program or the user selected size.

Steel Yield Strength (Fy)
User-specified yield strength for the beam.

Total Beam Length
Total length of the beam measured from the centerline of supports or, when there are cantilevers, from end of cantilever to end of cantilever. When cantilevers are present, the length of the cantilever and its position (right or left) along the beam is also shown.

Top Flange Braced/Unbraced
For non-composite beams, the specified bracing condition of the top flange.

Section Properties

This information will only be listed for built up sections or for asymmetric rolled sections.

Depth
Total depth of the steel section.

Tw
Web thickness.

BfTop
Top flange width.

TfTop
Top flange thickness.

BfBot
Bottom flange width.

TfBot
Bottom flange thickness.

Area
Total area of the steel section.

Ix
Moment of inertia of the steel section.

Composite Properties (for composite design)

Concrete Thickness
: Concrete thickness that exists above the flutes of the metal deck. The thickness is shown for the left and right side of the beam in case differences occur.

Unit Weight of Concrete
: Weight of the concrete. The weight is given for the left and right side of the beam in case differences occur.

f'c
: Strength of the concrete. The strength is given for the left and right side of the beam in case differences occur.

Decking Orientation
: Angle of the metal deck span, measured in degrees, from the referenced beam. The angle is given for the left and right side of the beam in case differences occur. The deck span will be considered “Parallel” with a beam if it is oriented within 10 degrees of that beam.

Decking Type
: Type of deck that was selected by the user. The deck type is given for the left and right side of the beam in case differences occur.

beff
: Effective concrete flange width used in the composite design of the beam.

Y bar
: Distance from the bottom of the steel beam to the neutral axis of the composite section used for deflection calculations.

Seff
: Effective section modulus of the composite section for partial composite action.

Str
: Section modulus for the transformed composite section referenced from the bottom flange of the steel beam.

Ieff
: Effective moment of inertia of the composite section for partial composite action.

Itr
: Moment of inertia for the transformed composite section.

Stud Length
: Nominal length of shear stud as selected by the user.

Stud Diameter
: Nominal diameter of the shear stud as selected by the user.

Stud Capacity (q)
: Shear capacity of a single shear stud. When multiple rows of studs are required, the shear capacity of a stud in a single row is indicated by q[1], that of a stud in a double row by q[2], and that of a stud in a triple row by q[3].

# of Studs
: Number of studs required for the design of the beam. The number of studs is given for full composite action (or maximum, if full composite action cannot be obtained), partial composite action and the actual number used. Unless otherwise specified by the user the actual and the partial number of studs will be the same. When there exists a point load on the designed beam, a series of studs may be listed with a comma

separating them. Each number represents the number of studs required between each point load or segment, starting at the left support.

Number of Stud Rows
Number of rows of studs necessary to place the number of studs called for.

Percent of Full Composite Action
Percent of full composite action corresponding to the number and distribution of studs specified for Actual.

User Defined Unbraced Top Flange Segments

This information will not be listed if the beam has been specified as Non-composite Unbraced Top Flange, and will only be listed if there are segments of the top flange that have been explicitly specified as unbraced.

From / To
Indicates the beginning and end of each segment of top flange that is unbraced.

User Defined Flange Brace Points

This information will be listed if there are any user-specified flange brace points (points at which the flange is braced against lateral translation or buckling).

Dist
Location of the flange brace point, measured from the left end of the beam.

Top
Indicates whether or not the top flange is braced at that location.

Bottom
Indicates whether or not the bottom flange is braced at that location.

Loading Information - Point Loads

Dist
Location of the point load represented as a distance measured from the left end of the beam.

DL
Magnitude of the dead load.

CDL
Magnitude of the construction (pre-composite) dead load.

LL
Magnitude of the live load.

CLL
Magnitude of the construction live load.

Flange Bracing
Indicates whether or not this point is also considered to be a compression flange brace point. Top Flange and Bottom Flange are indicated.

Loading Information - Line Loads

Load

This is the line load segment number. Each line load segment is defined by two rows of output: the beginning of the line load segment is listed on the same line of output as the segment number, the end of the line load segment is listed on the following line of output.

Dist

Distance, measured from the left end of the beam, to the beginning or end of a line load, for the given load segment.

DL

Magnitude of the dead load at Dist.

CDL

Magnitude of the construction (pre-composite) dead load at Dist.

LL

Magnitude of the live load at Dist.

CLL

Magnitude of the construction live load at Dist.

Shear

Max V

Maximum shear force in the member, with the controlling load combination listed.

fv

Actual shear stress, associated with the maximum shear.

Fv

Allowable shear stress.

Moments

This section gives the magnitude and location of the maximum positive and negative moments with the associated stresses.

Span

Span for which the values are being listed. It includes Left for left cantilever, Right for right cantilever, and Center for main span.

Cond

Load condition. It includes:

- PreCmp: Construction Dead Load and Construction Live Load (listed for composite beams only)
- InitDL: Initial, or Construction Dead Load (listed for composite beams only)
- Max +: Maximum Positive Moment
- Max -: Maximum Negative Moment
- Mmax/Seff: Stress condition based on the composite properties (listed for composite beams only)

Mconst/Sx+Mpost/Seff: Stress condition based on the superposition of stress (listed for composite beams only).

Moment

Moment for the indicated Span and Condition.

@

Location of the indicated moment, measured from the left end of the beam.

Lb

Unbraced length for the segment containing the indicated moment. If unbraced length was not considered, as for a simple span composite beam, Lb is indicated with “--”. Otherwise, if the compression flange is fully braced throughout the segment, Lb is indicated with “0.0”, meaning there is no unbraced length to be considered.

Cb

Bending Coefficient. If the unbraced length is zero, Cb is indicated with “---”.

fb

Actual bending stress in the beam for the moment indicated. Values for the Tension Flange and Compression Flange are included.

Fb

Allowable bending stress for the segment. Values for the Tension Flange and Compression Flange are included.

Controlling

Controlling set of values.

fc

Compressive stress in the concrete.

Fc

Allowable compressive stress in the concrete.

Reactions

This section gives the reactions at the supports due to various load conditions. Load conditions include: initial, dead load, maximum positive and negative live load, and maximum positive and negative total load.

Deflections - Center Span

If the beam has web openings, Multipliers for effects of Web Openings are listed. These values are all 1.0, indicating that the effects of web openings on the deflection have not been considered in the calculation of the deflections.

> **Note:** For the deflection values listed, (-) indicates downward deflection and (+) indicates upward deflection.

Initial Load

Deflection due to the initial loads (the construction dead load only). This deflection occurs prior to composite action. The location of the deflection output corresponds to the location of the maximum positive or negative total load deflection. As such it may not be the maximum deflection for this load case. Refer to the Technical Notes for further information. This is listed for composite beams only.

Dead Load

Deflection due to the dead load. The location of the deflection output corresponds to the location of the maximum positive or negative total load deflection. As such it may not be the maximum deflection for this load case. Refer to the Technical Notes for further information. This is listed for non-composite beams only.

Live Load

Deflection due to the live load (on the composite beam section for composite beams). The location of the deflection output corresponds to the location of the maximum positive or negative total load deflection. As such it may not be the maximum deflection for this load case. Refer to the Technical Notes for further information.

Post Com Load

Deflection due to the total load minus the initial load on the composite beam section. The location of the deflection output corresponds to the location of the maximum positive or negative total load deflection. As such it may not be the maximum deflection for this load case. Refer to the Technical Notes for further information. This is listed for composite beams only.

Net Total Load

Maximum deflection due to all loads, minus the specified camber, if any.

L/D

Span-to-deflection ratio.

Deflections - Cantilever

> **Note:** (-) indicates downward deflection and (+) indicates upward deflection.

Init load

Deflection at the end of the cantilever due to the initial load (i.e. construction dead load). This is listed for composite beams only. Dead Load: Deflection at the end of the cantilever due to the dead load. This is listed for non-composite beams only.

Pos Live Load

Deflection at the end of the cantilever due to the positive live load.

Neg Live Load

Deflection at the end of the cantilever due to the negative live load.

Pos Post Comp Load

Deflection at the end of the cantilever due to the total positive load minus the initial load. This is listed for composite beams only.

Neg Post Comp Load

Deflection at the end of the cantilever due to the total negative load minus the initial load. This is listed for composite beams only.

Pos Total Load

Total deflection on the end of the cantilever due to all positive loads.

Neg Total Load

Total deflection on the end of the cantilever due to all negative loads.

L/D

Span-to-deflection ratio.

Web Openings

This section lists the web opening geometry, stiffener design and analysis results.

In the Stiffener information, Sides indicates the number of sides of the beam web at which stiffeners are to be placed: 0 indicates no stiffeners, 1 indicates a pair of stiffeners on one side of web only, and 2 indicates a pair of stiffeners on both sides of web.

The weld size is listed and is assumed to be continuous on both sides of the stiffener plate for the full length.

Additional design requirements are also shown, including the minimum radii of the corners of rectangular openings, minimum slab reinforcement in the vicinity of the opening, and minimum stud requirements in the vicinity of the opening.

Design Warnings, if any, are listed for each opening. “Fail” is indicated for those conditions for which the opening or stiffener is unacceptable.

5.3.2 AISC 360-05 ASD and LRFD and AISC LRFD 3rd Edition

Most of the beam output for AISC 360-05 and LRFD 3rd is the same as ASD 9th. Therefore, only the items that are different are listed below.

Span Information

Mp: Plastic moment of the steel section for members designed non-composite.

Composite Properties

Mnf
Nominal flexural strength of the beam based on full composite action.

Mn
Nominal flexural strength of the beam based on partial composite action.

C
Effective concrete flange force based on partial composite action.

PNA
Plastic Neutral Axis of the composite section.

Shear Capacity (Qn)
Ultimate shear capacity of a single shear stud. When multiple rows of studs are required, the shear capacity of a stud in a single row is indicated by Qn[1], that of a stud in a double row by Qn[2], and that of a stud in a triple row by Qn[3].

Rg, Rp
For AISC 360-05 ASD and AISC 360-05 LRFD the capacity of each stud (Qn) is a function of the Rg and Rp parameters as described in Shear Stud Connectors . For each stud row the associated Rg and Rp values are also displayed as described for the shear capacity above.

Shear (Ultimate)

Max Vu
Maximum ultimate shear in the member.

Vn
Nominal shear capacity.

Moments (Ultimate)

This section gives the magnitude and location of the design moments with the associated capacities.

Span
Span for which the values are being listed. It includes Left for left cantilever, Right for right cantilever, and Span for main span.

Cond
Load condition. It includes:

- Pre Comp: Construction Dead Load and Construction Live Load (listed for composite beams only)
- Init DL: Initial, or Construction Dead Load (listed for composite beams only)
- Max +: Maximum Positive Moment
- Max -: Maximum Negative Moment

LoadCombo
Controlling Load Combination for the span and condition indicated.

Mu
Ultimate moment for the indicated Span, Condition and Load Combination.

@
Location of the indicated moment, measured from the left end of the beam.

Lb
Unbraced length for the segment containing the indicated moment. If unbraced length was not considered, as for a simple span composite beam, Lb is indicated with "---". Otherwise, if the compression flange is fully braced throughout the segment, Lb is indicated with "0.0", meaning there is no unbraced length to be considered.

Cb
Bending Coefficient. If the unbraced length is zero, Cb is indicated with "---".

Phi
This is the Resistance Factor for AISC 360-05 LRFD and LRFD 3rd editions.

W
This is the Omega factor for AISC 360-05 ASD.

Phi*Mn
This is the design strength of the beam segment for AISC 360-05 LRFD and LRFD 3rd.

Mn / W
This is the design strength of the beam segment for AISC 360-05 ASD.

5.3.3 CAN/CSA S16 01

This output contains a complete description of individual beam designs. Beam size, span length, yield strength, composite properties, loading patterns, moments, reactions and deflections are all included in this output.

Page Heading

The heading lists the current version of RAM SBeam, the Job Name and Description if specified by the user, the licensee Company name, and the date and time that the report was generated.

Steel Code

Steel Code
The steel design code selected and used in the design of the beam.

Span Information

Depth or Width Limitation Specified
If any beam depth or width limitations have been specified, they will be listed.
Beam Size
Designed beam size. It is either the optimum size selected by the program or the user selected size.
Steel Yield Strength (Fy)
User-specified yield strength for the beam.
Steel Design Yield Strength (Design Fy)
Design yield strength according to the steel grade and the rules of Table 6-3 in the CISC Handbook of Steel Construction 7th edition.
Grade
Designated grade for the section. See Design Yield Strength for more information on how the grade is determined.
Total Beam Length
Total length of the beam measured from the centerline of supports or, when there are cantilevers, from end of cantilever to end of cantilever. When cantilevers are present, the length of the cantilever and its position (right or left) along the beam is also shown.

Top Flange Braced/Unbraced
For non-composite beams, the specified bracing condition of the top flange.

Section Properties

This information will only be listed for built up sections or for unsymmetric rolled sections.

Depth
Total depth of the steel section.
Tw
Web thickness.
BfTop
Top flange width.
TfTop
Top flange thickness.
BfBot
Bottom flange width.
TfBot
Bottom flange thickness.
Area
Total area of the steel section.
Ix
Moment of inertia of the steel section.

Composite Properties (Composite Beams)

Concrete Thickness
Concrete thickness that exists above the flutes of the metal deck. The thickness is shown for the left and right side of the beam in case differences occur.

Unit Weight of Concrete
Weight of the concrete. The weight is given for the left and right side of the beam in case differences occur.

f'c
Strength of the concrete. The strength is given for the left and right side of the beam in case differences occur.

Decking Orientation
Angle of the metal deck span, measured in degrees, from the referenced beam. The angle is given for the left and right side of the beam in case differences occur. The deck span will be considered “Parallel” with a beam if it is oriented within 10 degrees of that beam.

Decking Type
Type of deck that was selected by the user. The deck type is given for the left and right side of the beam in case differences occur.

beff
Effective concrete flange width used in the composite design of the beam.

Y bar
Distance from the bottom of the steel beam to the neutral axis of the composite section.

Mrcf
Flexural strength of the composite beam based on full composite action.

Mrc
Flexural strength of the composite beam at the point of maximum moment, based on partial composite action.

C
Effective concrete flange force based on partial composite action.

PNA
Plastic neutral axis of the composite section.

St
Section modulus for the transformed composite section referenced from the bottom flange of the steel beam.

Ieff
Effective moment of inertia of the composite section for partial composite action.

Itr
Moment of inertia for the transformed composite section.

Stud Length
Nominal length of shear stud as selected by the user.

Stud Diameter
Nominal diameter of the shear stud as selected by the user.

Stud Capacity (qr)
Shear capacity of a single shear stud. When multiple rows of studs are required, the shear capacity of a stud in a single row is indicated by qr[1], that of a stud in a double row by qr[2], and that of a stud in a triple row by qr[3].

# of Studs

Number of studs required for the design of the beam. The number of studs is given for full composite action (or maximum, if full composite action cannot be obtained), partial composite action and the actual number used. Unless otherwise specified by the user the actual and the partial number of studs will be the same. When there exists a point load on the designed beam, a series of studs may be listed with a comma separating them. Each number represents the number of studs required between each point load or segment, starting at the left support.

Number of Stud Rows

Number of rows of studs necessary to place the number of studs called for.

Percent of Full Composite Action

Percent of full composite action that will be obtained if the number and distribution of studs conform to that specified for Actual. It represents the worst condition from any segment.

User Defined Unbraced Top Flange Segments

This information will not be listed if the beam has been specified as Non-composite Unbraced Top Flange, and will only be listed if there are segments of the top flange that have been explicitly specified as unbraced.

From / To

Indicates the beginning and end of each segment of top flange that is unbraced.

User Defined Flange Brace Points

This information will be listed if there are any user-specified flange brace points (points at which the flange is braced against lateral translation or buckling).

Dist

Location of the flange brace point, measured from the left end of the beam.

Top

Indicates whether or not the top flange is braced at that location.

Bottom

Indicates whether or not the bottom flange is braced at that location.

Loading Information - Point Loads

See Allowable Stress Design AISC for a description of this information.

Loading Information - Line Loads

See Allowable Stress Design AISC for a description of this information.

Shear

Max Vfx

Maximum shear force in the member and the load combination that resulted in this load.

Vrx

Shear capacity of the member.

Moments

This section gives the magnitude and location of the design moments with the associated capacities.

Span

Span for which the values are being listed. It includes Left for left cantilever, Right for right cantilever, and Center for main span.

Cond

This indicates the load condition. It includes:

- Pre Comp: Construction Dead Load and Construction Live Load (listed for composite beams only)
- Init DL: Construction Dead Load (listed for composite beams only)
- Max +: Maximum Positive Moment
- Max -: Maximum Negative Moment

LoadCombo

Controlling Load Combination for the span and condition indicated.

Mfx

Ultimate moment for the indicated Span, Condition and Load Combination.

@

Location of the indicated moment, measured from the left end of the beam.

Lb

Unbraced length for the segment containing the indicated moment. If the compression flange is fully braced throughout the segment, Lb is indicated with "---", meaning there is no unbraced length to be considered.

w2 (Omega2)

Equivalent uniform moment bending coefficient. If the unbraced length is zero w2 is indicated with "---".

Class

Section class based on the controlling loads for this condition.

Mrx

Design strength of the beam segment.

Controlling

Controlling set of values.

Tension Flange Stress

This section is applicable for unshored composite beams only.

Precomposite Moment

Design moment due to the loads that are applied to the bare beam prior to composite action. It only includes the Construction Dead Load.

Superimposed Moment

Design moment due to the loads applied to the beam after composite action occurs.

Mpre/Sx

Precomposite moment divided by the elastic section modulus of the bare beam, Sx. It is the stress caused by the precomposite moment.

Msuper/St
Superimposed moment divided by the effective section modulus of the composite beam, St. It is the stress caused by the superimposed moment.

Reactions

This section gives the reactions at the supports due to various load conditions. Load conditions include: initial, dead load, maximum positive and negative live load, and maximum positive and negative total load.

Deflections

nt
Modular ratio used in the calculation of shrinkage deflections of composite beams.

Refer to Allowable Stress Design AISC for definitions of additional items.

5.3.4 BS 5950

This output contains a complete description of individual beam designs. Beam size, span length, yield strength, composite properties, loading patterns, moments, reactions and deflections are all included in this output.

Page Heading

The heading lists the current version of RAM SBeam, the Job Name and Description if specified by the user, the licensee Company name, and the date and time that the report was generated.

Steel Code

Steel Code
The steel design code selected and used in the design of the beam.

Span Information

Depth or Width Limitation Specified
If any beam depth or width limitations have been specified, they will be listed.
Beam Size
Designed beam size. It is either the optimum size selected by the program or the user selected size.
Steel Nominal Yield Strength (py)
User-specified nominal yield strength for the beam.
Steel Design Yield Strength (Design py)
Design yield strength according to the steel grade and the rules of Table 6 in the BS5950:Part1:1990 Structural Use of Steelwork in Building.
Grade
See Design Yield Strength for more information on how the grade is determined.
Total Beam Length
Total length of the beam measured from the centerline of supports or, when there are cantilevers, from end of cantilever to end of cantilever. When cantilevers are present,

the length of the cantilever and its position (right or left) along the beam is also shown.

Top Flange Braced/Unbraced

For non-composite beams, the specified bracing condition of the top flange.

Section Properties

This information will only be listed for built up sections or for unsymmetric rolled sections.

Depth

Total depth of the steel section.

Tw

Web thickness.

BfTop

Top flange width.

TfTop

Top flange thickness.

BfBot

Bottom flange width.

TfBot

Bottom flange thickness.

Area

Total area of the steel section.

Ix

Moment of inertia of the steel section.

Composite Properties (Composite Beams)

Concrete Thickness

Concrete thickness that exists above the flutes of the metal deck. The thickness is shown for the left and right side of the beam in case differences occur.

Unit Weight of Concrete

Weight of the concrete. The weight is given for the left and right side of the beam in case differences occur.

fcu

Strength of the concrete (cube strength). The strength is given for the left and right side of the beam in case differences occur.

Decking Orientation

Angle of the metal deck span, measured in degrees, from the referenced beam. The angle is given for the left and right side of the beam in case differences occur. The deck span will be considered “Parallel” with a beam if it is oriented within 10 degrees of that beam.

Decking Type

Type of deck that was selected by the user. The deck type is given for the left and right side of the beam in case differences occur.

be

Effective concrete flange width used in the composite design of the beam.

Y bar

Distance from the bottom of the steel beam to the elastic neutral axis of the composite section.

Mcf
: Flexural strength of the composite beam based on full composite action.

Mc
: Flexural strength of the composite beam at the point of maximum moment, based on partial composite action.

C
: Effective concrete flange force based on partial composite action.

PNA
: Plastic neutral axis of the composite section.

Modular Ratio
: Effective modular ratio used in the calculation of the elastic section properties to the composite beam, considering the proportions of the loads that are long term and short term.

Ip
: Effective moment of inertia of the composite section.

Stud Length
: Nominal length of shear stud as selected by the user.

Stud Diameter
: Nominal diameter of the shear stud as selected by the user.

Stud Capacity (Qp)
: Shear capacity of a single shear stud. When multiple rows of studs are required, the shear capacity of a stud in a single row is indicated by Qp[1], that of a stud in a double row by Qp [2], and that of a stud in a triple row by Qp [3].

# of Studs
: Number of studs required for the design of the beam. The number of studs is given for full composite action (or maximum, if full composite action cannot be obtained), partial composite action and the actual number used. Unless otherwise specified by the user the actual and the partial number of studs will be the same. When there exists a point load on the designed beam, a series of studs may be listed with a comma separating them. Each number represents the number of studs required between each point load or segment, starting at the left support.

Number of Stud Rows
: Number of rows of studs necessary to place the number of studs called for.

Percent of Full Composite Action
: Percent of full composite action that will be obtained if the number and distribution of studs conform to that specified for Actual. It represents the worst condition from any segment.

User Defined Unbraced Top Flange Segments

This information will not be listed if the beam has been specified as Non-composite Unbraced Top Flange, and will only be listed if there are segments of the top flange that have been explicitly specified as unbraced.

From / To
: Indicates the beginning and end of each segment of top flange that is unbraced.

User Defined Flange Brace Points

This information will be listed if there are any user-specified flange brace points (points at which the flange is braced against lateral translation or buckling).

Dist
: Location of the flange brace point, measured from the left end of the beam.

Top
: Indicates whether or not the top flange is braced at that location.

Bottom
: Indicates whether or not the bottom flange is braced at that location.

Loading Information - Point Loads

See Allowable Stress Design AISC for a description of this information.

Loading Information - Line Loads

See Allowable Stress Design AISC for a description of this information.

Load Combinations

The load combinations considered in the design of the beam. These combinations are referenced by number in the Shear and Moment section as described below.

Shear

LCo
: Number of the load combination that controlled the shear design. In reference to the load combinations listed above.

Max Fvx
: Maximum shear force in the member.

Pvx
: Shear capacity of the member.

Moments

This section gives the magnitude and location of the design moments with the associated capacities.

Span
: Span for which the values are being listed. It includes Left for left cantilever, Right for right cantilever, and Center for main span.

Cond
: Load condition. It includes:

- Pre Comp: Construction Dead Load and Construction Live Load (listed for composite beams only)
- Init DL: Construction Dead Load (listed for composite beams only)
- Max +: Maximum Positive Moment
- Max -: Maximum Negative Moment

LCo
Controlling Load Combination for the span and condition indicated. The number refers to the load combinations listed in the Load Combination section above.

Mx
Ultimate moment for the indicated Span, Condition, and Load Combination.

Fvx
Shear at the location of the ultimate moment for the indicated Span, Condition, and Load Combination.

@
Location of the indicated moment and shear, measured from the left end of the beam.

Lb
Unbraced length for the segment containing the indicated moment. If the compression flange is fully braced throughout the segment, Lb is indicated with "---", meaning there is no unbraced length to be considered.

mLT
Equivalent uniform moment bending coefficient. If the unbraced length is zero mLT is indicated with "---".

Type
Designation of the controlling section capacity. Mcx represents full non-composite capacity with no reduction for shear load. Mvx represents the full non-composite capacity with a reduction for shear load. Mbx represents the bending capacity controlled by lateral torsional buckling. Mc represents the composite beam capacity with no reduction for shear load. Mcv represents the composite beam capacity reduced for shear load.

Capacity
Controlling bending capacity of the beam segment. Refer to the type to determine what controlled the design.

Controlling
Controlling set of values.

Flange Stress

This section is applicable for composite beams only.

Precomposite Moment
Design moment due to the loads that are applied to the bare beam prior to composite action. It only includes the Construction Dead Load. This value is listed for unshored (unpropped) beams only.

Superimposed Moment
Design moment due to the loads applied to the beam after composite action occurs. This value is listed for unshored (unpropped) beams only.

Mpre/Zx
Precomposite moment divided by the elastic section modulus of the bare beam, Zx. It is the steel stress caused by the precomposite moment. This value is listed for unshored (unpropped) beams only.

Msuper/Zt
Superimposed moment divided by the effective section modulus of the composite beam, Zt. It is the steel stress caused by the superimposed moment. This value is listed for unshored (unpropped) beams only.

Unfactored Moment

Design moment due to the total loads applied to the beam. This value is listed for shored (propped) beams only.

Munf/Zt

Unfactored moment divided by the effective section modulus of the composite beam, Zt. It is the steel stress caused by the total unfactored moment. This value is listed for shored (propped) beams only.

fconc

Stress in the concrete caused by the superimposed moment for unshored (unpropped) construction, or the stress in the concrete caused by the total moment for shored (propped) construction.

Reactions

This section gives the reactions at the supports due to various load conditions. Load conditions include: initial, dead load, maximum positive and negative live load, and maximum positive and negative total load.

Vibration

This section gives the frequency characteristics for checking vibration requirements.

Ig for Vibration

Full composite moment of inertia based on the short term modular ratio.

Deflection

Deflection of the beam with the full Dead Load and 10% of the imposed load applied, using Ig.

Beam Frequency, Simplified Method: Beam frequency. See Vibration Analysis .

Deflections

If the beam has web openings, Multipliers for effects of Web Openings are listed. These values indicate the factor by which the deflection for the given condition was increased to account for the effects of the web openings on the deflection.

Refer to Allowable Stress Design AISC for definitions of additional items.

Web Openings

This section lists the web opening geometry, stiffener design and analysis results.

In the Stiffener information, Sides indicates the number of sides of the beam web at which stiffeners are to be placed: 0 indicates no stiffeners, 1 indicates a pair of stiffeners on one side of web only, and 2 indicates a pair of stiffeners on both sides of web.

The weld size is listed and is assumed to be continuous on both sides of the stiffener plate for the full length.

Design Warnings, if any, are listed for each opening. “Fail” is indicated for those conditions for which the opening or stiffener is unacceptable.

Transverse Reinforcing

This section gives the transverse reinforcing required to resist the longitudinal shear.

Reinforcement fy
Yield strength of the reinforcement.

Total Longitudinal v
Total longitudinal shear.

Longitudinal v
Longitudinal shear to be resisted on the side of the beam indicated.

pyp
Design yield strength of the profiled steel sheeting.

tp
Thickness of the profiled steel sheeting.

Sheeting Continuous
Indicator for the condition of the profiled steel sheeting continuous (Yes) or discontinuous (No) over the top flange of the beam.

vp
Contribution of the profiled steel sheeting to resist the longitudinal shear.

Req'd Asv
The required area of transverse reinforcement per unit length of beam.

5.3.5 Eurocode

Most of the beam output for Eurocode is the same as ASD. Therefore, only the items that are different are listed below.

Span Information

Steel Yield Strength (fy)
User-specified yield strength for the beam.

Steel Design Yield Strength (Design fy)
Design yield strength.

Gamma M0, Gamma M1, Gamma Gj,sup, Gamma Gj,inf, Gamma Q,1, Gamma C, Gamma V

These factors are provided by the engineer and are used in the calculation of member capacities. Refer to the Eurocode and National Annex for appropriate values to be provided.

Composite Properties

fck
Characteristic strength of the concrete.

Mpl.Rd
Plastic resistance moment of the section with full shear connection (full composite action).

MRd
Plastic resistance moment of the section with partial shear connection (partial composite action).

C
Effective concrete flange force based on partial composite action.

PNA
Plastic Neutral Axis of the composite section.

Pstud/PRd
The ratio of the actual shear in each shear connector and the shear resistance of a shear connector, and is used to determine the value of composite I to be used in the deflection calculations.

Load Combinations

This section lists the load combinations used in the beam design. These are referred to by the load combination number in the following sections.

Shear

This section provides a check of the shear capacity of the section for the maximum shear that occurs at the support.

LCo
Controlling Load Combination, (i.e., load combination that produces the largest shear).

VEd
The maximum factored design shear load at the support.

Vpl,Rd
The plastic shear capacity of the beam.

Moments

This section gives the magnitude and location of the design moments with the associated capacities.

Span
Span for which the values are being listed. It includes Left for left cantilever, Right for right cantilever, and Center for main span.

Cond
This indicates the load condition. It includes:

- Pre Comp: Construction Dead Load and Construction Live Load (listed for composite beams only)
- Init DL: Construction Dead Load (listed for composite beams only)
- Max +: Maximum Positive Moment
- Max -: Maximum Negative Moment

Controlling
This is the controlling set of values.

LCo
Controlling Load Combination for the span and condition indicated.

Class
Class of the section subject to the indicated loads. Only class 1 and 2 can be designed as composite sections.

MEd
Factored moment for the indicated Span, Condition and Load Combination..

VEd

Factored shear load for the indicated Span, Condition and Load Combination.

@

Location of the indicated moment, measured from the left end of the beam.

Lb

Unbraced length for the segment containing the indicated moment. If unbraced length was not considered, as for a simple span composite beam, Lb is indicated with "---". Otherwise, if the compression flange is fully braced throughout the segment, Lb is indicated with "0.0", meaning there is no unbraced length to be considered.

MRd

The text represent the controlling equation for the calculated capacity:

- Mc.y.Rd: Beam plastic bending capacity,
- Mv.y.Rd: Beam bending capacity reduced for shear load,
- Mb.y.Rd: Beam capacity considering lateral buckling,
- MRd: Composite beam plastic capacity.

Capacity

Design strength of the beam segment.

5.4 Smartbeam Design Output

The following is a brief description of the output provided by RAM SBeam for Smartbeam designs.

> **Note:** Output in English (US Imperial), SI or metric units can be obtained by setting the model units on the General Criteria dialog Units tab .

5.4.1 AISC 360-05 ASD (13th Edition)

This output contains a complete description of individual Castellated Smartbeam designs. Size, hole configuration, studs, loads, and design checks are included. The report for Cellular Smartbeams is similar.

Page Heading

The heading contains information about RAM Steel and the model that the output represents. It lists the current version of RAM Steel being used, the title of the output, the database name including the date and time it was created or last modified and the building and steel codes that were utilized in the design process. It may also include the licensee Company name and a project description.

Span Information

Beam Coordinates

These are the coordinates at the ends of the beam.

Duct Size Specified

If a duct size, for which the holes in the web must be large enough to accommodate, has been specified, it will be listed. H and B represent the vertical dimension and width

dimension, respectively, of a rectangular duct, and Diam represents the diameter of a round duct.

Beam Depth Limitation Specified

If a beam depth limitation has been specified, it will be listed.

Beam Size

This is the designed beam size. It is either the optimum size selected by RAM Steel or the user-specified size.

Steel Yield Strength (Fy)

This is the user selected yield strength for the beam.

Top

This is the size of the wide flange beam from which the top piece of the Smartbeam is made.

Bottom

This is the size of the wide flange beam from which the bottom piece of the Smartbeam is made.

dt

This represents the distance from top of flange to top of opening.

emin, emax

For an optimized beam this represents the range of acceptable e values.

e

This represents a specified e value.

phi top

This represents the range of angles for the top castellation. A user-specified phi represents an angle of the top castellation.

phi bottom

This represents the range of angles for the bottom castellation. A user-specified phi represents an angle of the bottom castellation.

b

This represents the adjacent edge of the angled side of the castellated opening.

Tee Depth at Web Post

This represents the tee depths at the web post.

Depth

This represents the total depth of the Smartbeam. For Cellular beams, a range of depth corresponds to a range of spacing. Castellated beam depths do not change with the range of e.

Connection Type

This is the connection type designated for this beam, for both the Left and Right (I and J) ends of the beam..

Total Beam Length

This is the total length of the beam measured from the center line of supports.

Opening Data

Center of First Opening from I-End

This the distance of the centerline of the first opening measured from the I-End of the beam

Center of Last Opening from J-End

This the distance of the centerline of the last opening measured from the J-End of the beam

Number of openings in beam

This the number of openings in the beam.

Infill location

This the distance of the centerline of openings with infills measured from the I-End of the beam.

Location of Transfer Columns

This the distance of the centerline of transfer columns measured from the I-End of the beam

Geometric Error

These are geometric error warnings resulting from an analyzed user specified geometry.

Castellated Beams

2h/e > 8

e/tw > 30

dt > 0.5 depth

dt < tf + 1.0 in

h/tw > 970/sqrt(Fy)

phi < 58 Deg.

phi > 62 Deg.

Cellular Beams

e > 3.0 in

S/D < 1.08

S/D > 1.50

depth/D < 1.25

depth/D > 1.75

dt < tf + 1.0 in

h/tw > 970/sqrt(Fy)

Composite Properties (for composite design)

Stud Capacity (Qn)

This is the shear capacity of a single shear stud. When multiple rows of studs are required, the shear capacity of a stud in a single row is indicated by Qn[1], that of a stud in a double row by Qn[2], and that of a stud in a triple row by Qn[3].

Shear (Ultimate) - Gross

Max Vu

This represents the maximum factored shear force in the member.

Vn

This represents the nominal shear capacity of the member.

ΩVu/Vn

This represents the ratio of the actual shear to the shear capacity.

Shear (Ultimate) – Net

Max Vu

This represents the maximum factored shear force at any hole in the member.

Vu

This represents the portion of MaxVu carried by the tee. A value for both the top and the bottom tee are listed.

Vn

This represents the nominal shear capacity of the tee. A value for both the top and the bottom tee are listed.

ΩVu/Vn

This represents the ratio of the actual shear to shear capacity of the tee. A value for both the top and the bottom tee are listed.

Shear (Ultimate) - Horizontal

Max Vave

This represents the maximum average shear force between any two adjacent holes, used in Method 3 for noncomposite and precomposite.

Vu

This represents the actual shear force on the web post, corresponding to the Method indicated.

Control Vu

This represents the worst shear force, of any of the three methods, on the web post.

Vn

This represents the nominal shear capacity of the web post.

ΩVu/Vn

This represents the ratio of the actual shear to shear capacity of the web post.

Web Post Buckling

Max Vu

This represents the maximum shear force in the web post.

Mu

This represents the maximum factored design moment on the web post.

Mp

This represents the plastic moment capacity of the web post.

Mocr

This represents the critical moment capacity of the web post.

Ω

This represents the Ω factor used to reduce the nominal moment capacity, Mn.

Mn

This represents the nominal moment capacity of the web post.

ΩMu/Mn

This represents the ratio of the actual moment-to-moment capacity on the web post.

Vierendeel

Vc
This represents the shear capacity of the concrete on the beam (composite beams only).

Vu
This represents the shear in the beam at the controlling hole.

Mu
This represents the moment in the beam at the controlling hole.

Pu
This represents the axial force in the tee.

Mu
This represents the bending moment in the tee. The values from the primary moment and the secondary moment are listed, as well as the total of those two values.

Pn
This represents the nominal axial capacity in the tee.

H1-1a, H1-1b
This represents the interaction equation results for the tee.

Moments

This section gives the magnitude and location of the maximum positive and negative moments with the associated stresses.

Span
This indicates the span for which the values are being listed, which is always listed as Center since cantilevers are not allowed for Smartbeams.

Cond
This indicates the load condition. It includes:

- Pre Cmp: Precomposite load (Construction Dead Load plus Construction Live Load; listed for composite beams only)
- Init DL: Construction Dead Load (listed for composite beams only)
- Max +: Maximum Positive Moment
- Max -: Maximum Negative Moment

LoadCombo
This is the controlling Load Combination for the indicated Condition.

Mu
This is the ultimate moment for the indicated Condition and Load Combination.

@
This is the location of the indicated moment, measured from the left end of the beam.

Lb
This is the unbraced length for the segment containing the indicated moment. If the compression flange is fully braced throughout the segment, Lb is indicated with “0.0”, meaning there is no unbraced length to be considered. Listed for noncomposite beams only.

Cb
This is the Bending Coefficient. Listed for noncomposite beams only.

Ω
This is the Resistance Factor. Listed for noncomposite beams only.

Mn/Ω
This is the design strength of the segment. Listed for noncomposite beams only.

Controlling
This is the controlling set of values. Listed for noncomposite beams only.

5.4.2 AISC 360-05 LRFD (13th Edition)

Most of the output for Smartbeams for AISC 360-05 LRFD is the same as for AISC 360-05 ASD. Only the items that are different are listed below. The information shown is for Castellated Smartbeams; the information for Cellular Smartbeams is similar.

Shear (Ultimate) - Gross

Vu/ΦVn
This represents the ratio of the actual shear to the shear capacity.

Shear (Ultimate) – Net

Vu/ΦVn
This represents the ratio of the actual shear to shear capacity of the tee. A value for both the top and the bottom tee are listed.

Shear (Ultimate) - Horizontal

Vu/ΦVn
This represents the ratio of the actual shear to shear capacity of the web post.

Web Post Buckling

Mu/ΦMn
This represents the ratio of the actual moment-to-moment capacity on the web post.

5.4.3 AISC ASD (9th Edition)

This output contains a complete description of individual Castellated Smartbeam designs. Size, hole configuration, studs, loads, and design checks are included. The report for Cellular Smartbeams is similar.

Composite Properties (for composite design)

Concrete Thickness
This is the concrete thickness above the flutes of the metal deck. The thickness is shown for the left and right side of the beam in case differences occur.

Unit Weight of Concrete
This is the weight of the concrete. The weight is given for the left and right side of the beam in case differences occur.

f'c
This is the strength of the concrete. The strength is given for the left and right side of the beam in case differences occur.

Decking Orientation

This is the angle of the metal deck span, measured in degrees, from the referenced beam. The angle is given for the left and right side of the beam in case differences occur. The deck span will be considered "Parallel" with a beam if it is oriented within 10 degrees of that beam.

Decking Type

This is the type of deck that was selected by the user. The deck type is given for the left and right side of the beam in case differences occur.

beff

This is the effective concrete flange width used in the composite design of the beam.

Ieff

This represents the effective moment of inertia of the composite section for partial composite action.

Itr

This represents the moment of inertia for the transformed composite section.

Stud Length

This is the nominal length of shear stud as selected by the user.

Stud Diameter

This is the nominal diameter of the shear stud as selected by the user.

Stud Capacity (q)

This is the shear capacity of a single shear stud. When multiple rows of studs are required, the shear capacity of a stud in a single row is indicated by q[1], that of a stud in a double row by q[2], and that of a stud in a triple row by q[3].

# of Studs

This is the number of studs required for the design of the beam. The number of studs is given for full composite action (or maximum, if full composite action cannot be obtained), partial composite action and the actual number used. Unless otherwise specified by the user the actual and the partial number of studs will be the same.

Number of Stud Rows

This is the number of rows of studs necessary to place the number of studs called for.

Percent of Full Composite Action

This is the percent of full composite action that will be obtained if the number and distribution of studs conform to that specified for Actual.

Loading Information - Point Loads

See Allowable Stress Design AISC for a description of this information.

Loading Information - Line Loads

See Allowable Stress Design AISC for a description of this information.

Shear - Gross

Max V

This represents the maximum shear force in the member.

fv

This represents the actual shear stress, associated with the maximum shear.

Fv

This represents the allowable shear stress.

fv/Fv
: This represents the ratio of the actual to allowable shear stress.

Shear - Net

Max V
: This represents the maximum shear force at any hole in the member.

fv
: This represents the actual shear stress on the tee, associated with the maximum shear. A value for both the top and the bottom tee are listed.

Fv
: This represents the allowable shear stress on the tee. A value for both the top and the bottom tee are listed.

fv/Fv
: This represents the ratio of the actual to allowable shear stress. A value for both the top and the bottom tee are listed.

Shear - Horizontal

Max Vave
: This represents the maximum average shear force between any two adjacent holes, used in Method 3 for noncomposite and precomposite design.

fv
: This represents the actual shear stress on the web post, corresponding to the Method indicated.

Controlling fv
: This represents the worst shear stress, of any of the three methods, on the web post.

Fv
: This represents the allowable shear stress on the web post.

fv/Fv
: This represents the ratio of the actual to allowable shear stress on the web post.

Composite Max Vh
: This represents the maximum horizontal shear in the web post for the composite condition.

Web Post Buckling

Max Vh
: This represents the maximum horizontal shear in the web post.

Mmax
: This represents the design moment on the web post.

Mp
: This represents the plastic moment capacity of the web post.

Mocr
: This represents the critical moment capacity of the web post.

F.S.
: This represents the Factor of Safety used in calculating the allowable moment capacity, Mallow.

Mallow
: This represents the allowable moment capacity of the web post.

Mmax/Mallow
This represents the ratio of the actual to allowable moments on the web post.

Vierendeel

Vc
This represents the shear capacity of the concrete on the beam (composite beams only).

V
This represents the shear in the beam at the controlling hole.

M
This represents the moment in the beam at the controlling hole.

fa
This represents the axial stress in the tee.

fb
This represents the bending stress in the tee.

Fa
This represents the allowable axial stress in compression in the tee.

Ft
This represents the allowable axial stress in tension in the tee.

Fb
This represents the allowable bending stress in the tee.

H1-1, H1-2, H2-1
This represents the interaction equation results for the tee.

Moments

This section gives the magnitude and location of the maximum positive and negative moments with the associated stresses.

Span
This indicates the span for which the values are being listed, which is always listed as Center since cantilevers are not allowed for Smartbeams.

Cond
This indicates the load condition. It includes:

- Precmp: Precomposite load (Construction Dead Load plus Construction Live Load; listed for composite beams only)
- InitDL: Construction Dead Load (listed for composite beams only)
- Max +: Maximum Positive Moment
- Max -: Maximum Negative Moment

Moment
This is the moment for the indicated Condition.

@
This is the location of the indicated moment, measured from the left end of the beam.

Lb
This is the unbraced length for the segment containing the indicated moment. If the compression flange is fully braced throughout the segment, Lb is indicated with “0.0”, meaning there is no unbraced length to be considered. Listed for noncomposite beams only.

Cb
This is the Bending Coefficient. Listed for noncomposite beams only.

fb

This is the actual bending stress in the beam for the moment indicated. Values for the Tension Flange and Compression Flange are included. Listed for noncomposite beams only.

Fb

This is the allowable bending stress for the segment. Values for the Tension Flange and Compression Flange are included. Listed for noncomposite beams only.

Controlling

This is the controlling set of values. Listed for noncomposite beams only.

fc

This is the compressive stress in the concrete. Listed for composite beams only.

Fc

This is the allowable compressive stress in the concrete. Listed for composite beams only.

Reactions

This section gives the reactions at the supports due to various load conditions. Load conditions include: initial, dead load, maximum positive and negative live load, and maximum positive and negative total load.

Deflections - Center Span

Refer to Allowable Stress Design AISC for definitions of additional items.

5.4.4 AISC LRFD (3rd Edition)

Most of the output for Smartbeams for AISC LRFD is the same as for AISC 360-05 ASD. Only the items that are different are listed below. The information shown is for Castellated Smartbeams; the information for Cellular Smartbeams is similar.

Shear (Ultimate) - Gross

Vu/0.90Vn

This represents the ratio of the actual shear to the shear capacity.

Shear (Ultimate) – Net

Vu/0.90Vn

This represents the ratio of the actual shear to shear capacity of the tee. A value for both the top and the bottom tee are listed.

Shear (Ultimate) - Horizontal

Vu/0.90Vn

This represents the ratio of the actual shear to shear capacity of the web post.

Web Post Buckling

phib

This represents the phi factor used to reduce the nominal moment capacity, Mn.

Mu/phibMn
This represents the ratio of the actual moment-to-moment capacity on the web post.

5.4.5 Detailed Smartbeam Design

This output contains a complete description of individual Castellated Smartbeam designs; the information for Cellular Smartbeams is similar.

Design checks on posts and openings are reported for beam configurations matching the minimum and maximum cases of e. Output for a controlling cases of e is reported when it differs from the either the minimum or maximum.

Most of the output for the Detailed Smartbeam Design is the same as for Smartbeam Design. Only the items that are different are listed below. Tee section properties, loads, opening configurations, and design checks are also included.

Dt
This represents the distance from top of flange to top of opening

Emin, Emax
This represents the range of acceptable e values.

Econtrolling
This represents the e value in the range of e that resulted in the controlling interaction.

Tee Properties at Center of Opening
This represents the section properties of the top and bottom tees at the center of an opening.

Tee Properties at Critical Section
This represents the section properties of the top and bottom tees at the critical section of 0.45R from center line of opening (Cellular Beams Only).

Precomposite Shears and Moments
This represents the precomposite shears and moments at each opening in the member.

Composite Shears and Moments
This represents the precomposite shears and moments at each opening in the member.

Shear at Net Section
This represents the net shear checks at each opening in the member.

Horizontal Shear
This represents the horizontal shear checks at each post in the member.

Web Post Buckling
This represents the web post buckling checks at each post in the member.

Precomposite Vierendeel
This represents the precomposite Vierendeel checks at each opening in the member.

Composite Vierendeel
This represents the composite Vierendeel checks at each opening in the member.

5.5 Diagrams

Descriptions of the diagram types created in RAM SBeam.

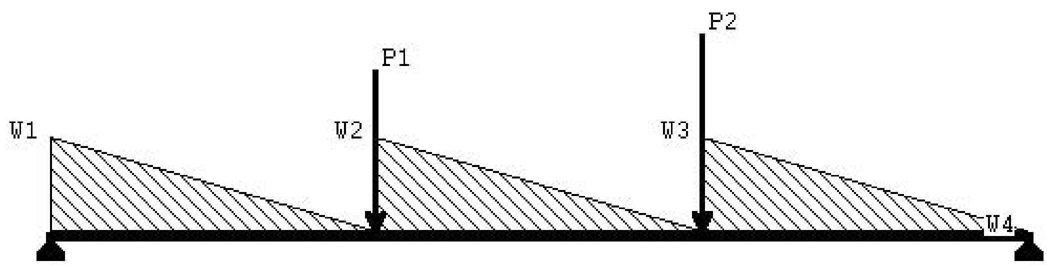
5.5.1 Load Diagram

Graphical and numerical display of the loads on the beam.

A printout of the Load Diagram is available by selecting **Reports** > **Load Diagram**.

The heading lists the current version of RAM SBeam, the Job Name and Description if specified by the user, the licensee Company name, and the date and time that the report was generated.

Figure 5-1: An example load diagram and table



Load	Dist	DL	LL+	LL-	Max Tot
P1	11.58	21.325	7.997	0.000	29.322
P2	23.15	26.278	9.854	0.000	36.133
W1	0.00	0.315	0.118	0.000	0.434
W2	11.58	0.000	0.000	0.000	0.000
		0.315	0.118	0.000	0.434
W3	23.15	0.000	0.000	0.000	0.000
		0.315	0.118	0.000	0.434
W4	34.73	0.000	0.000	0.000	0.000

Below the load diagram, the load information is listed including: deal load, positive live load, negative live load and maximum total load.

Load

Load identifier used in the diagram.

Dist

Distance from the beam end to this load.

DL

Total Dead Load value at the distance specified.

LL+

Total reduced Live Load value of downward acting loads.

LL-

Total reduced Live Load value of upward acting loads, if any.

Max Tot

Maximum total combined Dead and Live Loads.

W1

Magnitude of the uniform or trapezoidal load at the distance specified. When two values are listed at a given point, the first value indicates the magnitude directly to the left of the point and the second value indicates the magnitude directly to the right of the point.

P1

Magnitude of the concentrated load at the distance specified.

5.5.2 Shear, Moment, and Deflection Diagrams

Graphical and numerical displays of the internal beam forces.

A print out of the shear, moment, and deflection diagrams is available by selecting the Print button in the View Diagrams command in View/Update Beam dialog .

The diagrams show the Dead Load, Maximum Total Load, and Minimum Total Load diagrams. The diagrams are based on factored values for LRFD. The maximum shear and moment values are also listed.

Chapter 6
Menus

A description of the menu bar items.

6.1 File menu

Contains items for creating, opening, and closing SBeam files, printing, and exiting the program.

Table 6-1: File menu items

File menu item	Description	Shortcut
New	Closes the current design and opens an empty design. **Note:** If the current SBeam file has unsaved changes, a warning dialog prompts to save the file or cancel the action.	CTRL+N
Open...	Opens the Open dialog, which is used to open an existing RAM SBeam file.	CTRL+O

File menu item	Description	Shortcut
Save	Used to Save changes made to the current SBeam file. **Note:** If the current file has not been saved (the title bar displays "Untitled"), then this command has the same effect as selecting **File > Save As...**	CTRL+S
Save As...	Used to save the current SBeam file with a different file name and/or in a different location.	
Job Information...	Opens the Job Information dialog , which is used to specify optional descriptive information on the project which is then included in report headers.	
Print Screen...	Prints the contents of the View window. **Tip:** Use the Print Setup dialog to change your print preferences.	
Print Preview	Opens the Print Preview window, which displays the print output on screen using the current Print Setup settings.	
Print Setup...	Opens the Print Setup dialog, which is used control the paper settings used when **File > Print Screen** is selected.	
# **Recent File List**	Contains a list of up to ten of the most recently opened	ALT+F+corresponding number key

File menu item	Description	Shortcut
	SBeam files. Selecting one of the items in this list opens that file.	
Exit	Closes the program. **Note:** If the current SBeam file has unsaved changes, a warning dialog opens prompting you to save the file or cancel the action.	ALT+F4

6.1.1 Job Information dialog

Used to specify optional descriptive information on the project which is then included in report headers.

Dialog Controls

Job Name
Enter a job or project name for inclusion in report headers.
Comments
Enter optional comments or identification information for the beam design.
Show this dialog when Print is issued

Select this option to have the Job Information dialog opened when either **Reports** > **Beam Design** or **Reports** > **Load Diagram** is selected.

Tip: This option is useful if you make several changes in the same file to generate multiple reports.

OK
Closes the dialog and updates any changes made.
Cancel
Closes the dialog without saving any changes.
Help
Opens the RAM SBeam Help window to a related help topic.

6.2 Criteria menu

Contains items for reviewing and changing criteria used for beam design.

Table 6-2: Criteria menu items

Criteria menu item	Description
General...	Opens the General Criteria dialog, which is used specify the database tables and units used in the current SBeam file.
Design...	Opens the Design Criteria dialog, which is used to specify the design code used and code related parameters.
Deflection...	Opens the Deflection Criteria dialog, which is used to set deflection limits for various stages of construction of different types of beams (composite and non-composite).
Camber...	Opens the Camber Criteria dialog, which is used to
Web Openings...	Opens the Web Openings dialog, which is used to
S martbeams...	Opens the Smartbeams dialog, which is used to

6.2.1 General Criteria dialog

Used to specify general, program-wide options such as tables and units.

Dialog Controls

The following controls are common to all tabs in this dialog:

Save as Default
: Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK
: Closes the dialog and updates any changes made.

Cancel
: Closes the dialog without saving any changes.

Help
: Opens the RAM SBeam Help window to a related help topic.

General Criteria dialog Tables tab

To display and/or change table selections for decks and sections.

Dialog Controls

Using the selection controls on this tab, you can specify the deck table and steel tables to be used for design. Several deck and steel tables are supplied with RAM SBeam. The folder where the table files are located is displayed on this dialog to help locate the tables for editing.

Deck Table

Deck properties are taken from the selected table file.

Master Table

Member sizes and section properties are taken from the selected table file.

Beam Design Table

A list of section sizes to be considered for design is taken from the selected table file.

Castellated Beam Table

Smartbeam sizes and section properties for castellated beams are taken from the selected table file.

Cellular Beam Table

Smartbeam sizes and section properties for cellular beams are taken from the selected table file.

Note: Deck and steel tables may be modified and created. For further explanations on customizing steel and deck tables, refer to Appendix A.

General Criteria dialog Units tab

To display and/or change the current system of units.

Dialog Controls

Units

The program is capable of working in English, SI, and Metric units. At any time during data input or design the system of units may be changed as desired. This capability is useful in the case where you may be required to produce a design in units with which you are unaccustomed.

Note: When the program is first invoked, all default values are set based on the system default units. When the Units are changed, current data values are converted; the units-specific defaults (e.g., Yield Strength has a different default value for English units than for SI units) are *not* automatically assigned. Selecting **File** > **New**will reset all defaults to the units-specific values.

6.2.2 Design Criteria dialog

Used to select a design code and specify design parameters for that standard.

Dialog Controls

The following controls are common to all tabs in this dialog:

Save as Default
: Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK
: Closes the dialog and updates any changes made.

Cancel
: Closes the dialog without saving any changes.

Help
: Opens the RAM SBeam Help window to a related help topic.

Design Criteria dialog Code tab

To display and/or modify the current beam Design Code.

Dialog Controls

Code
: Contains a list of available design codes and, in the case of ASD 9th Edition, optional design provisions. Codes which are not available for the selected material type are inactive.

> **Note:** Selecting certain codes may result in additional tabs being made available for specifying the appropriate code-specific criteria.

Design Criteria dialog Studs tab

Used to display and/or change the current Stud Criteria.

Dialog Controls

Stud criteria may be changed for the current beam data by typing the desired values in the appropriate edit boxes, and then selecting the OK button. Selecting the Cancel button will cancel any new selections made.

Percent of Full Composite Allowed
: Specify the percentage of full composite action to be used for **Maximum %** and **Minimum %**.

Stud Distribution
: Select if the distribution of studs along the length of the beam top flange is a **Uniform Distribution** or should be an **Optimized Distribution** to reduce the number of studs.

Maximum Rows of Studs Allowed
: Specify the maximum number of parallel rows of studs along the length of the beam top flange.

Minimum Flange Width for 2/3 Rows of Studs
: Specify the minimum flange width specified for either two or three parallel rows of studs, respectively.

Maximum Stud Spacing

The **Limit To** option of Maximum Stud Spacing should be used cautiously to avoid unintended results. Remember that for beams with skew decks, the distance between flutes measured along the length of the beam is increased. Too small values of Spacing may conflict with the rib spacing. Otherwise, use the **Per Code** option to let the program evaluate a maximum stud spacing value.

If beam fails minimum composite requirements

Select to either **Use Bare Beam section properties** or **Use Composite section properties** for the condition in which the beam fails minimum composite requirements.

Composite Ieff

(AISC codes only) Select the option to **Reduce Ieff per AISC 360 Commentary (0.75)**to reduce the effective composite composite moment of inertia by 25% (i.e., multiply Ieff by 0.75). Refer to the Technical Notes section on Deflection for additional information.

Design Criteria dialog Design Defaults tab

To display and/or change miscellaneous beam design parameters

Dialog Controls

Design default criteria may be changed for the current beam data by typing the desired values in the appropriate edit boxes.

Check Unbraced Length

Select this option to calculate the bending capacity considering the bracing conditions of the flanges. Left unselected the top and bottom flange will be considered fully braced, irrespective of actual physical conditions, when determining the sections bending capacity.

Consider Point of Inflection

This option does not mean that the Point of Inflection will or will not be considered a brace point; rather, it affects the way the program looks at brace points of the flanges on either side of the point of inflection when determining the unbraced length. Refer to the manual (Help - Manual) for a complete explanation.

Precomposite Beam Design

For composite beams in their pre-composite state, the program can consider the top flange as being braced by a supported deck, provided that the appropriate checkbox is selected. Selecting "Deck perpendicular to Beam Braces flange" results in the top flange of the beam being braced if the beam supports a deck, which is more than 10 degrees off the axis of the beam. Selecting "Deck parallel to Beam Braces flange" results in the top flange of the beam being braced if the beam supports a deck which is less than 10 degrees off the axis of the beam.

Additional Design Defaults for BS 5950

Use mLT=1.0 on Simple Span Beams

Select this option to set the equivalent uniform moment factor to 1.0 for all simple beam (pinned supports with no cantilevers). The mLT is defined in the BS 5950 Draft Amendment, Dated April 1998, Section 4.3.6.2. and BS 5950-1:2000, Section 4.3.6.6.

Use mLT=1.0 on all Cantilevers

Select this option to set the equivalent uniform moment factor to 1.0 for the cantilever portion of a beam. Note that if left unselected the mLT will still be set to 1.0 on cantilever when BS 5950:1990 is selected (as required by BS 5950 Draft Amendment, Dated April 20th, 1998, Table 4.4.). However, if BS5950-1:2000 is the design code, mLT will be calculated according to Table 18 footnotes unless the engineer explicitly sets mLT=1.0 for cantilevers.

According to 4.3.5.3c of BS5950-1:2000, the lateral buckling capacity of the unsupported flange of beams directly supporting a concrete or composite floor is calculated according to G.2. Where this check is required in a structure, RAM SBeam will assume that mLT is 1.0 and will calculate an nt value according to G.4.2.

Beam Effective Length

In calculating the effective length for lateral torsional buckling the end conditions of the unbraced segment must be considered. A beam fixed at a column (as in the case of a beam cantilevering through a column) is provided an effective length factor of 0.7 for that end. A beam continuous through a lateral support (due to a framing beam) is provided an effective length factor of 1.0 for that end. The effective length factor for the segment is taken as the average of the effective length factors from the two ends. As no connection details are available to RAM SBeam the engineer is responsible for providing the effective length factor to be used at the end of cantilevers and at pin supports.

Modular Ratio

In the calculation of the deflection of Composite beams, BS 5950 requires that an effective modular ratio be used in the calculation of the elastic section properties. This modular ratio is a function of the proportion of long-term and short-term loads. The user can specify a value to be used by selecting the Use option, and then specifying a value. Alternately, the user can specify that the program compute the value by selecting the Calculate option. The percentages of each of the Live Load types that are to be considered long-term must then be specified. The modular ratio would then be calculated based on the loads on the beam.

Additional Design Defaults for CAN/CSA S16

Use w2 = 1.0 on Simple Span Beams

Select this option to set the equivalent uniform moment factor to 1.0 for all simple beam (pinned supports with no cantilevers). The w2 factor is defined in CAN/CSA-S16-01 Section 13.6.

Use w2 = 1.0 on all Cantilevers

Select this option to set the equivalent uniform moment factor to 1.0 for the cantilever portion of a beam. Note that even if left unselected the w2 will always be 1.0 on a cantilever as specified by the *SSRC Stability Design Criteria for Metal Structures*, Galambos, 1998. This reference specifies a w2 of 1.0 but increases the unbraced length by 1.5 for the cantilever beam segment.

Additional Design Defaults for Eurocode

Use C = 1.0 on Simple Span Beams

Select this option to set the C1, C2 and C3 factors to 1.0 for calculating the Mcr value for all simple beams (pinned supports with no cantilevers).

Use C = 1.0 on all Cantilevers

Select this option to set the C1, C2 and C3 factors to 1.0 for the cantilever portion of a beam. These factors are used to calculate the Mcr value for all simple beams (pinned supports with no cantilevers).

For More Information, refer to the Technical Notes chapter.

Design Criteria dialog Steel Material tab

(CAN/CSA-S16-01 only) Used to enter material parameters if Canadian specifications are to be used for member design.

When CAN/CSA-S16-01 is selected as the Steel Beam Design Code, the Steel Material tab is available to specify steel grade for the various shapes.

Select a steel grade for **Rolled W**, **WWF**, **HSS Rect**, or **Channel** shape classes. The steel material type (Table 6-3 from CISC Handbook, Eighth Edition) for each type of structural member must be provided.

The designated steel material type is combined with the nominal yield strength assigned to each individual member to determine the steel grade and the design yield strength of the section. For example, a section of type W with a nominal Fy of 350N/mm2 is assigned a steel grade of 350W. A nominal Fy of slightly less than 350 will result in a steel grade of 300W. Specifying a nominal Fy and material type that has no matching steel grade will result in a design yield strength of 0.0 and no grade assignment.

Design Criteria dialog Vibration tab

(BS 5950 only) Used to enter vibration criteria if BS 5950 specifications are to be used for member design.

When BS 5950 is selected as the Steel Beam Design Code, the Vibration tab is available to specify limits on the frequency of composite beams.

The frequency is calculated by a simplified method using the following equation:

Fz =18/sqrt (deflection)

The deflection is based on the full composite section using the short term modular ratio under Dead Load and 10% of the Live Load. Ig may be increased 10% to account for increased stiffness of the beam under dynamic loading, such as for the effects of continuity. If the size fails the specified limit, a larger size will be used when optimizing beam sizes. A value of 0.0 specified for the minimum frequency means that there is no minimum limit on the frequency; specify 0.0 if the simplified vibration approach is not to be used.

Dialog Controls

Minimum Frequency, Short /Long Span Beams
Different frequency limits can be set for both short span and long span beams.

Long spans are longer than
The transition span length between short span and long span.

Design Criteria dialog Bison PC Units tab

(BS 5950 only) To display and/or change the current Bison Precast Units criteria.

Selecting the **Criteria** > **Design**command will cause the Design Criteria dialog box to appear. When BS 5950 is selected as the Steel Beam Design Code, the **Bison PC Units** tab is available with the current Precast Criteria shown.

> **Note:** Some items can be specified by the user, other items are shown for informational purposes only to show the values that the program will be using in the design of composite beams with the Bison Precast units.

Bearing Width
Bearing Width is the required width of bearing of the precast unit on the beam flange.

Slab Tolerance
Slab Tolerance is the manufacture tolerance of the precast unit.

Construction Tolerance
Construction Tolerance is the manufacturer and construction tolerance of the steel beam.

The gap between planks at the supporting beam is determined based on the beam flange width, the required Bearing Width of the plank, the Slab Tolerance, and the Construction Tolerance . The beam design will be rejected if the resulting gap width is less than 30mm, and a wider beam will be selected. A gap of at least 30mm is necessary in order to fit the studs between the precast units. The gap value is also used in the determination of the effective flange width.

Information regarding the transverse reinforcement and the precast units is also displayed to indicated the values that will be used by the program. These values can not be modified by the user.

Design Criteria dialog Steel Section Options tab

(BS 5950 only) Used to enter material and design criteria if BS 5950 specifications are to be used for member design.

When BS 5950:2000 is selected as the Steel Beam Design Code, the Steel Section Options tab is available to specify the type of Hollow Structural Section used and the location of lateral restraint relative to the top of steel.

Dialog Controls

Hollow Sections

Select if these sections are designated as Hot-Rolled or Cold-Formed. This designation affects the classification of the cross section (see table 12 in BS5950-1:2000), and the web shear interaction as described in H.3 of BS5950-1:2000.

Distance to Axis of Restraint

Distance top-of-section to axis of restraint applies to a beam which is fully braced at the top flange. The dimension entered is used in calculating the lateral torsional buckling capacity of beams with fully restrained tension flange (hogging region) per 4.3.5.3c and Annex G.2. of BS5950-1:2000.

BS 5950-1:2000 has changed the method in which the lateral torsional bending capacity of beams is calculated. In certain circumstances, where the tension flange of a beam is fully braced and the compression flange unbraced, the height of the restraint to the tension flange affects the bending capacity of the member (See BS 5950-1:2000 4.3.5.3c, Annex G.1. and G.2.). This will typically affect the design of cantilever or continuous members in the zone where the unbraced lower flange is in compression. The engineer can stipulate the distance from the top-of-flange (tension), to the center of the restraint of that flange, in this dialog.

Design Criteria dialog Eurocode Factors tab

(Eurocode only) To enter the design factors if Eurocode specifications are to be used for member design.

Dialog Controls

When Eurocode is selected as the Steel Beam Design Code, the Eurocode Factors tab is available to specify parameters required for the successful analysis and design of structures according to the Eurocode specifications. A number of factors used in the Eurocode may vary from country to country. Their values are specified in the individual country's National Annex (NA). You may specify these values as appropriate.

Partial Safety Factors

Load factors for load combination generation and member resistance factors for adjusting member capacity.

Composite Beam Design

Factors used in the design of composite beams. Refer to EN 1993-1-1 for additional information.

Design fy

To indicate whether the design fy of beams, columns and/or braces should be reduced according to the member thickness as described in the Eurocode.

Beam Lateral Torsional Buckling (Zg=0)

Specify whether loads applied along the length of the section are applied at the top flange or at the shear center. The selected option will impact the magnitude of Mcr by setting the Zg value equal to zero if the load is applied at the shear center.

6.2.3 Deflection Criteria dialog

Used to maximum allowable deflection ratios or values considered to be acceptable for a variety of loaded and composite conditions. The separate tabs are used for the deflection criteria of Composite - Unshored, Composite- Shored, and Non-composite beams, with the current deflection criteria for beam optimization specified on each tab.

Opens when **Criteria** > **Deflection**is selected.

Dialog Controls

The following two method are available for specifying a deflection criteria for any of the loading or composite flag conditions:

L/d
: The minimum span-to-deflection ratio (i.e., higher ratios result in a smaller acceptable deflection).

delta
: The absolute maximum deflection value, in the specified units. A value of 0.0 indicates no limit for this condition.

Save as Default
: Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK
: Closes the dialog and updates any changes made.

Cancel
: Closes the dialog without saving any changes.

Help
: Opens the RAM SBeam Help window to a related help topic.

6.2.4 Camber Criteria dialog

Used to indicate the conditions under which a camber value will be specified for a beam for either composite or non-composite construction.

Opens when **Criteria** > **Camber...** is selected.

The amount of camber required can be reduced or eliminated by specifying a more stringent Deflection Criteria for Initial deflection for Unshored Composite beams, and for Dead Load deflection for Noncomposite and Shored composite beams. This will result in the selection of a deeper and/or heavier beam that requires less or no camber.

The camber criteria may affect the member size selection if the Net Total Deflection controls the design. By limiting or suppressing the amount of camber, the program will select a deeper and/or heavier beam to satisfy the Net Total Deflection criteria.

Dialog Controls

Do Not Camber
: Selecting this option prevents the program from considering camber for the beam.

Camber Except When...
Camber can also be suppressed by specifying conditions when, if met, no camber is specified. When values are specified as 0.0 for Camber Except When options, those options will not be considered.

% DL Used for Camber
For unshored composite construction, the indicated percent of construction (pre-composite) dead load is used to determine the required camber. For non composite and shored composite construction, the indicated percentage of the total dead load is used

Camber Increment
When the camber is calculated, the value is rounded down to the Increment value specified.

Minimum Camber
If the camber required is less than this value, no camber is specified for that member.

Maximum Camber
If the camber required is greater than this value, the Maximum Camber value will be used for that member.

> **Note:** This does not necessarily mean that the program will select a beam that does not need additional camber (greater than the Maximum value), it merely means that the amount of camber called out will be limited to the Maximum. Generally a more appropriate way of limiting the maximum camber is to specify more stringent deflection criteria; that causes a larger beam to be selected that does not need as much camber.

Save as Default
Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK
Closes the dialog and updates any changes made.

Cancel
Closes the dialog without saving any changes.

Help
Opens the RAM SBeam Help window to a related help topic.

6.2.5 Web Openings dialog

Used to specify steel material, dimensions, and locations for web opening stiffeners.

Openings in the webs of I-shaped steel beams are specified in the Layout Web Openings dialog . This data includes location, shape and size of the opening. During optimization or analysis of the beam, the effects of the web openings on the beam are considered. If necessary, the program will design stiffeners above and below the openings. The criteria for the stiffeners can be specified in the Web Opening Criteria dialog box.

Opens when **Criteria** > **Web Openings...** is selected.

Dialog Controls

Stiffener Fy
Specify the yield strength of the stiffener plates.

Stiffener Dimensions

Specify the minimums and increments of the dimensions of the stiffener plates. The program will select stiffeners, when necessary, that are sized as required but that are at least the minimum size specified. The sizes are rounded up to the multiple of the increment specified.

Stiffener Location

Stiffeners placed on only one side of the web are often acceptable and more economical. They are not always desirable, however, because they cause the beam to be asymmetrical (which can be a problem in cases of long unbraced lengths). The program will investigate the design of web openings with stiffeners on one side of the web if that option is selected, otherwise it will not.

> **Note:** It may be more economical to use deeper, heavier beams rather than adding stiffeners. If neither option to allow stiffeners is selected, the program will optimize to the beam size that does not require stiffeners at the openings. On the other hand, if depth of beams is a concern, lighter, shallower beams may be acceptable if stiffeners are allowed.

Save as Default

Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK

Closes the dialog and updates any changes made.

Cancel

Closes the dialog without saving any changes.

Help

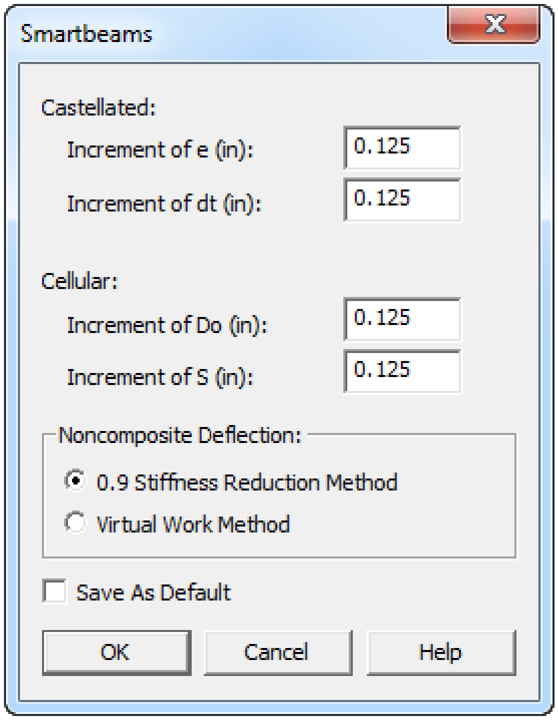
Opens the RAM SBeam Help window to a related help topic.

6.2.6 Smartbeams dialog

Used to specify design parameter options for the design of Smartbeams.

Opens when **Criteria** > **Smartbeams**is selected.

Figure 6-1: The Smartbeams dialog



Dialog Controls

Increment of e

Specify the increment (in displayed units) for the clear edge distance used in castellated beams design.

Increment of dt

Specify the increment (in displayed units) for the depth of castellated beam design.

Increment of Do

Specify the increment (in displayed units) for the depth of the circular web openings in cellular beam designs.

Increment of S

Specify the increment (in displayed units) for the spacing of circular web openings in cellular beam designs.

Noncomposite Deflection

Select either the **0.9 Stiffness Reduction Method** or **Virtual Work Method** option to use in the determination of the noncomposite deflection.

Save as Default

Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK

Closes the dialog and updates any changes made.

Cancel

Closes the dialog without saving any changes.

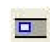
Help

Opens the RAM SBeam Help window to a related help topic.

6.3 Beam menu

Contains items used to define the beam model.

Table 6-3: Beam menu items

Beam menu item	Description	Shortcut
Span Definition...	Opens the Span Definition dialog , which is used to define span lengths and general beam properties.	
C omposite...	Opens the Composite dialog , which is used to edit composite deck and rib spacing details.	
Bracing...	Opens Bracing dialog , which is used to define discrete top or bottom flange braces as well as unbraced top flange segments.	
Web Opening...	Opens the Layout Web Openings dialog , which is used to add or edit beam web openings.	
Duct Size...	Opens Duct Size dialog , which is used to specify duct size and shape to be considered for the design of Smartbeams™.	

6.3.1 Span Definition dialog

Used to specify span length, materials, composite action, and design restrictions.

Dialog Controls

The following controls are common to both View/Update dialogs:

OK

Closes the dialog and updates any changes made.

Cancel

Closes the dialog without saving any changes.

Help

Opens the RAM SBeam Help window to a related help topic.

(Steel beam) Span Definition dialog

Used to specify the span information, including span and cantilever lengths, material properties, type, span/depth limits and size restrictions.

Dialog Controls

Span Length

Specify the length of beam span and, if present, the length of left and/or right cantilevers.

> **Note:** The graphic displays solid lines for active cantilever ends. Otherwise, these are displayed as dashed lines and are ignored for design.

Type

Indicate the type of floor or roof decking system for this beam:

- Composite
- Noncomposite - Braced Top Flange (the top flange of the beam is laterally braced by the deck)
- Noncomposite - Unbraced Top Flange (the top flange of the beam is not laterally braced by the deck).

For example, a noncomposite deck with the flutes perpendicular to the beam may be considered to provide lateral bracing to the top flange of the beam, while a noncomposite deck with the flutes parallel to the beam may be considered inadequate to provide lateral bracing to the top flange of the beam. If either Noncomposite option is selected, the Composite menu item in the Beam menu bar will be disabled.

In almost all cases the bracing condition of the compression flange can be specified by indicating whether or not the deck braces the top flange as described above, and by indicating whether or not points of concentrated loads should be considered as brace points for the top and/or bottom flange. In some cases, however, it may be necessary to define additional brace points (such as would be provided by an angle brace kicker) or to define the locations of segments of the beam where the deck does not provide bracing to the top flange (such as when a beam frames through a floor opening). This can be done from the Bracing Dialog.

> **Note:** If **Composite** or **Noncomposite - Unbraced Top Flange** is selected, the Additional Unbraced Segments data is ignored; it only needs to be entered if **Noncomposite - Braced Top Flange** is entered but there is a segment along the beam where the deck does not provide bracing.

Material Properties

The shape and yield strength of the member are specified in this Material Properties section. The shape is any of I Section, Channel or Rectangular Hollow Section. Note that web openings can only be assigned to I Sections.

Size Restriction

Size restrictions may be assigned to accommodate design constraints by entering the maximum and minimum acceptable depths as well as a minimum width. If no size restrictions are desired, select None, which is the default. Any beam which is assigned

a size restriction will be optimized utilizing that restriction. You will be warned if no steel beam of the depth or width specified passes the design criteria and the deflection criteria, and the optimum size will then be selected by the program.

To specify a maximum depth, check the box next to the Maximum Depth option and enter a value in the Maximum Depth edit box. This is an absolute depth, not a nominal depth.

To specify a minimum depth, check the box next to the Minimum Depth option and enter a value in the Minimum Depth edit box. This is an absolute depth, not a nominal depth.

To specify a minimum width, check the box next to the Minimum Width option and enter a value in the Minimum Width edit box.

Maximum Span/Depth Ratio

The minimum beam or joist depth can be controlled by specifying a value for Maximum Span/Depth Ratio. When selecting optimized sizes the program selects members that are at least deep enough to satisfy this criteria. This is a common rule-of-thumb, not a Code requirement. Common values are 20 to 24. Note that you must use consistent units – ft/ft or m/m. A value of 0.0 indicates no limit.

(Smartbeams) Span Definition dialog

Used to define the span, material properties, end conditions, and size restrictions for a Smartbeam design.

Dialog Controls

Note: Refer to the (steel beam) Span Definition dialog description for additional information on common dialog elements.

Span Length

Specify the length of the beam span.

Note: Cantilevers are not allowed for Smartbeams. If cantilever dimensions were entered in the Steel Span Definition dialog before selecting the Smartbeam material, these values will be removed.

Material Properties

Select to use either **Castellated** or **Cellular** beams. The yield strength, **Fy**, is also specified here.

Type

Select if the beam is composite or, if not, if the top flange is braced by other means (i.e., a metal deck).

Span/Depth Limit

Provide an optional span-to-depth **Ratio** which will limit how shallow the beam depth can be with respect to the beam span.

Connection Type
For both the Left and Right end of the beam, select if the beam is connected by the beam **Web** or by flange **Bearing**.

Size Restriction
Select the option to Use one or more size restrictions for beam depth or flange width. Select the option(s) you wish to use and specify an appropriate maximum or minimum value.

6.3.2 Composite dialog

Opens when **Beam** > **Composite**is selected.

Dialog Controls

The following controls are common to both tabs in this dialog:

OK
Closes the dialog and updates any changes made.

Cancel
Closes the dialog without saving any changes.

Help
Opens the RAM SBeam Help window to a related help topic.

Composite dialog Decking tab

Used to specify and/or change the composite deck, concrete, and stud properties.

Opens when **Beam** > **Composite**is selected.

The deck and concrete information necessary for composite design is entered on the Decking tab.

Dialog Controls

Deck Span
Provide the distance of the adjacent beam or slab edge. The program will automatically calculate the effective flange width based on the data provided here. The distance to slab edge can be specified as 0.0.

Studs
Provide the stud material property and length. This data is used to calculate the stud capacity for composite design.

Deck and Fill
The program allows for differing concrete and deck profiles on either side of the beam. For each side, enter the appropriate information. The beam can be specified as shored ("propped") which will affect pre-composite and deflection calculations.

Concrete Thickness Above Flutes

Enter the thickness of concrete above the flutes of the deck.

> **Note:** For flat slab and Bison (UK Only) decks, the thickness refers to the total concrete thickness.

Concrete strength

Specify the appropriate concrete strength for composite section strength calculation.

Unit Weight

Specify the concrete unit weight. This value is used to determine the deflection characteristics of the section and is not used for self weight calculations. Specify the appropriate tributary slab self weight from the loads menu command.

> **Note:** For Bison slabs (UK deck table only), the unit weight value is not used as it is specified by the manufacturer.

Orientation

Enter the angle of the deck relative to the beam.

> **Note:** A rotation angle of either 0 or 180 degrees represents deck that is parallel to the beam. Ninety degrees represents deck perpendicular to the beam.

Deck Type

Select the deck type to be used on each side from the Deck list box. Several deck property types are included with RAM SBeam. You may make additions or deletions to this table by editing the deck table files (file extension `.dck`) in the `TABLES` Directory. See the Manual (available from the Help menu) for an explanation on modifying this table. The Deck list box contains all Deck Types currently available in the database.

Save as default

By selecting the save as Default options the appropriate values can be set to the `RAMSBeam.ini` file and will be the default values used for all new files from that point on.

Composite dialog Ignore Rib Spacing tab

Used to display and/or change the option to ignore the rib spacing when determining the stud spacing.

Opens when **Beam** > **Composite**is selected.

Dialog Controls

Ignore Rib Spacing when Determining Stud Spacing

When the deck is skewed with respect to the beam and the angle between the deck and the beam is very small, there may be very few ribs crossing the beam in which to put studs. It is sometimes impossible to fit the number of studs required for minimum composite action due to the long spacing between ribs. In actual

construction practice, the required number of studs can be forced to fit either by splitting the deck – forming a concrete haunch down the length of the beam – or by cutting or flattening the ribs as necessary to place the studs. The user can indicate that the spacing of the ribs is to be ignored, allowing the program to design those beams as composite beams. This is done by selecting the Ignore Rib Spacing when Determining Stud Spacing option.

When this option is selected, the stud spacing is not limited to the rib spacing; rather, the minimum allowable stud spacing is used instead, when determining the number of studs that can fit along the beam.

When overriding the rib spacing the engineer can designate that the deck is either Split or Altered, as shown graphically in the dialog box. The option that is selected for Condition has an impact on the design.

Normally this option should not be selected, as it may result in the specification of a quantity of studs that cannot be conveniently placed on the beam (within the ribs) without modifying the deck.

6.3.3 Bracing dialog

Used to define discrete top or bottom flange braces as well as unbraced top flange segments.

Opens when **Beam** > **Bracing...** is selected.

Dialog Controls

Additional Brace Points

To specify additional brace points, enter the distance from the left end of the beam to the brace point and select Top Flange and/or Bottom Flange. To delete a brace point from the list, select the row in the grid corresponding to that brace point, and click the Delete key. To change a brace point in the list, simply edit the data in the cell for that brace point.

Additional Unbraced Segments (Top Flange)

To specify segments of unbraced top flange, enter the distance from the left end of the beam to the left end of the segment, enter the distance from the left end of the beam to the right end of the segment. To delete an unbraced segment from the list, select the corresponding row in the grid and click the Delete key. To change an unbraced segment in the list, simply edit the data in the grid for that unbraced segment.

> **Note:** If **Non-Comp: Unbraced Top Flange** is selected in the Span Definition dialog , the Additional Unbraced Segments data is not available to enter data and previously existing data is ignored. This data only needs to be entered if **Composite** or **Non-Comp: Braced Top Flange** is entered but there is a segment along the beam where the deck does not provide bracing. For composite beams this unbraced segment is only considered for the pre-composite load condition.

Save as Default

Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK

Closes the dialog and updates any changes made.

Cancel

Closes the dialog without saving any changes.

Help

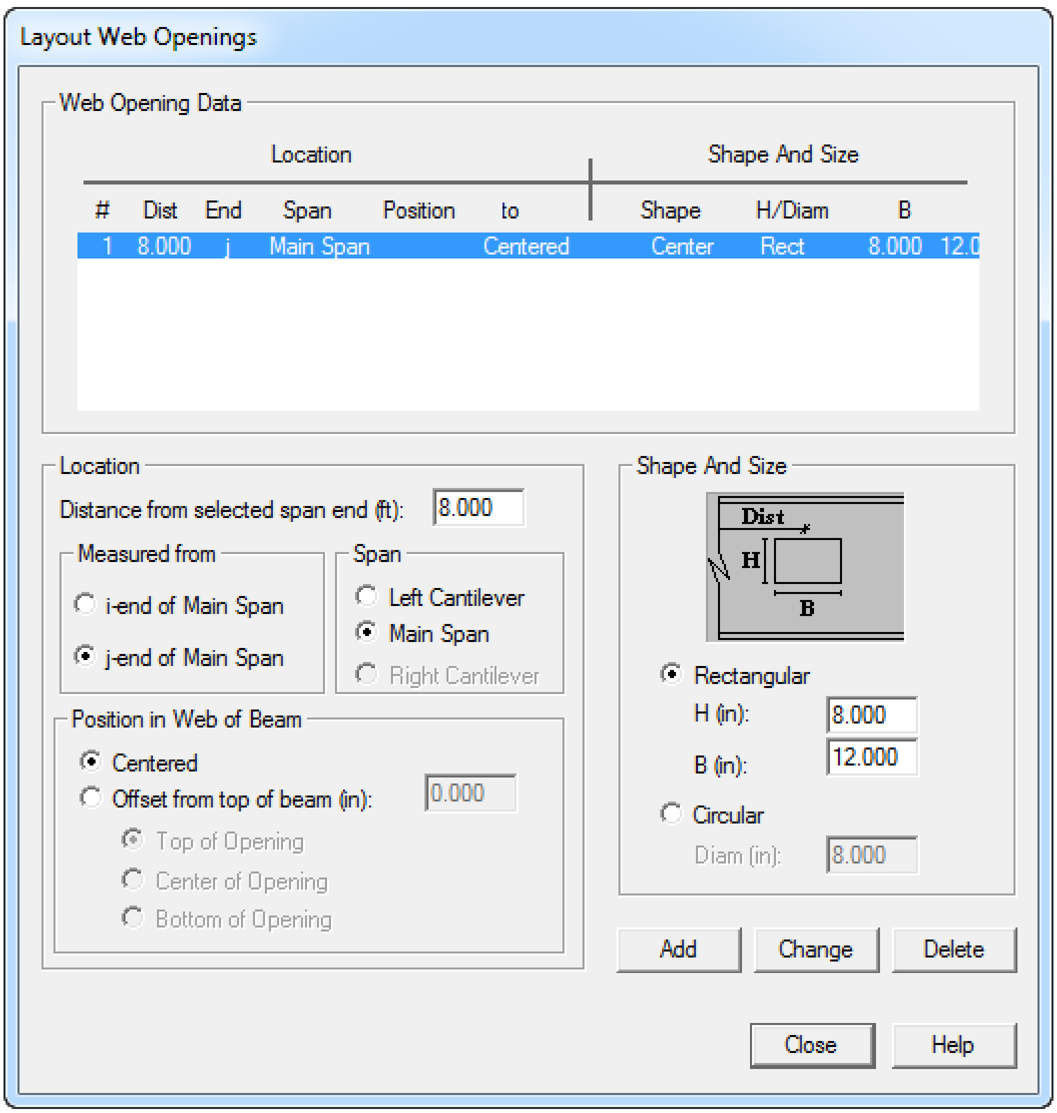
Opens the RAM SBeam Help window to a related help topic.

6.3.4 Layout Web Openings dialog

Used to add or edit web openings in the steel beam.

Opens when **Beam** > **Web Openings** command will cause the Layout Web Openings dialog box to appear.

Figure 6-2: The Layout Web Openings dialog



Dialog Controls

Web Opening Data list

The Web Opening Data section displays the location and dimensions of any web openings in the beam span. Specifically, it shows the span end from which it was measured, the distance from that point, the shape of the web opening, the dimensions of the opening, and the position in the web. Selecting an entry in this list allows you to modify or delete the selected opening.

Location

Specify the **Distance from selected span end**, which **Span** in which the web opening is located, and the end from which the distance is **Measured from**.

Position in Web of Beam

Specify the location of the web opening within the depth of the beam web. Select either the **Centered** or **Offset from top of beam** option. For the latter option, specify the length of the offset and to which point on the opening the offset is measured (i.e., top, center, or bottom).

Shape And Size

Specify the general shape type of the web opening (i.e., Rectangular or Circular) as well as the dimensions for the selected shape. The diagram displays the nomenclature for the selected shape type.

Add

Adds a new opening to the beam using the current web opening details.

Change

Updates the selected web opening (i.e., the entry highlighted in the Web Opening Data list) to the current web opening details.

Delete

Removes the selected web opening (i.e., the entry highlighted in the Web Opening Data list) from the beam.

Close

Closes the dialog.

Help

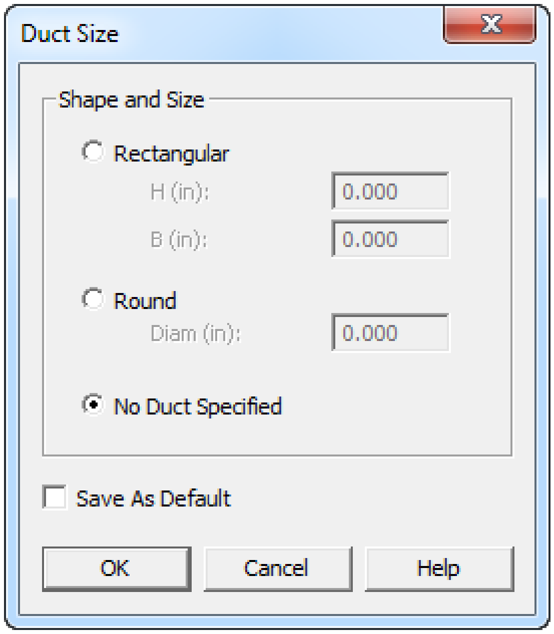
Opens the RAM SBeam help window.

6.3.5 Duct Size dialog

Used to specify mechanical duct size and shape to be considered for the design of Smartbeams.

Opens when **Beam** > **Duct Size...** is selected.

Figure 6-3: The Duct Size dialog



Upon designing a Smartbeam with duct size data provided, the program will select a beam of sufficient depth and with an opening of sufficient size to allow the duct of the specified size and shape to pass through. The holes in the web of Castellated beams are always hexagonal, but the size of the openings in the web will be selected such that a duct of the size and shape specified will be able to pass through the hexagonal opening.

This feature should only be used for small or moderate size holes. If very large web penetrations are needed, a web post may be removed and the section reinforced. If this is required, contact CMC Steel Products directly for assistance.

Dialog Controls

Select one of the following options to allow for ducts in the design of Smartbeams:

Rectangular
: Specify a height (**H**) and width (**B**) for rectangular ducts.

> **Note:** This is *not* in reference to the shape of the hole, but rather the geometry of the duct which will pass through one of the web holes.

Round
: Specify the **Diam**eter of the duct for round ducts.

No Duct Specified
: (Default) Select this option when no ducts are considered in the design. If the current beam design is for a specified duct size, this may be cleared by selecting this option.

Save as Default
: Selecting this option will set any changes made to the dialog as the default parameter upon clicking the **OK** button.

OK
: Closes the dialog and updates any changes made.

Cancel

Closes the dialog without saving any changes.

Help

Opens the RAM SBeam Help window to a related help topic.

6.4 Loads menu

Contains items for adding, changing, and removing loads along the beam.

Table 6-4: Loads menu items

Loads menu item	Description	Shortcut
Load Cases...	Opens the Loads dialog , which is used to view and/or change loads on the beam.	
Clear Loads...	Removes all loads currently applied to the beam.	

6.4.1 Loads dialog

The Loads dialog contains four tabs which are used to specify the loads on the member. If a member is not loaded with a particular load type, the information for that type need not be specified. However, loads from the previous design run must be revised or reset to zero if they differ from the current run; they do not automatically revert back to zero.

Opens when **Loads** > **Load Cases...** is selected.

Note: Refer to Member Loads for additional information on each load type considered in the program.

After loads are specified, they are shown graphically on the screen.

Dialog Controls

The following controls are common to all tabs in this dialog:

OK

Closes the dialog and updates any changes made.

Cancel

Closes the dialog without saving any changes.

Help

Opens the RAM SBeam Help window to a related help topic.

Loads dialog Uniform Load tab

Displays the current uniform load data. This load will be applied along the entire length of the beam, including cantilevers, if any.

Dead / Construction Dead / Live / Construction Live Load
: Input loads in the specified units in the corresponding fields. Any or all fields may be left empty if no uniform load of a given type need be considered.

Consider Beam Self-Weight
: Select this option to superimpose the weight of the beam onto the uniform dead load.

Loads dialog Partial Uniform Load tab

Used to add load over a portion of the beam with non-varying magnitude.

Load table

Any number of Partial Uniform loads can be specified. Each row represents a different partial uniform load, with the following data for each column:

DL
: Dead Load

CDL
: Construction Dead Load

LL
: Live Load

CLL
: Construction Live Load

Start
: Distance to the start of the loaded portion (left end of the load), as measured from the far left end of the beam.

End
: Distance to the end of the loaded portion (right end of the load), as measured from the far left end of the beam.

Loads dialog Trapezoidal Load tab

Used to add loads over a portion of the beam with linearly varying magnitude along the length of the portion.

Load table

A pair of rows is used for each trapezoidal load to specify the magnitudes that occur on the **Left** and **Right** ends of the loaded segment, respectively, as well as the Distance to the Right or Left end of the loaded segment. The following describes each column:

> **Tip:** When there are multiple loads, the loads can overlap.

DL
: Dead Load

CDL
: Construction Dead Load

LL
: Live Load

CLL
: Construction Live Load

Distance
: Distance to the end for the Left or Right end of the loaded segment (corresponding to the selection in the row pair) as measured from the left end of the beam.

Tip: If one row is left blank, then the result is a triangular load.

Loads dialog Concentrated Loads tab

Used to add point loads anywhere along the beam. The program can also consider these as flange brace points.

Load table

Any number of concentrated loads can be specified. Each row represents a different concentrated load, with the following data for each column:

DL
: Dead Load

CDL
: Construction Dead Load

LL
: Live Load

CLL
: Construction Live Load

Distance
: Distance to the end for the Left or Right end of the loaded segment (corresponding to the selection in the row pair) as measured from the left end of the beam.

Braces Top / Bot Flange
: Select these option to consider the load as bracing the Top and/or Bottom Flange as appropriate (e.g., where the concentrated load is from another beam framing in such a way as to provide lateral flange bracing). This has the same effect as assigning flange brace points using the Bracing dialog .

Tip: If one row is left blank, then the result is a triangular load.

6.5 Process menu

Contains items for initiating the beam design and reviewing, saving, or clearing design results.

Table 6-5: Process menu items

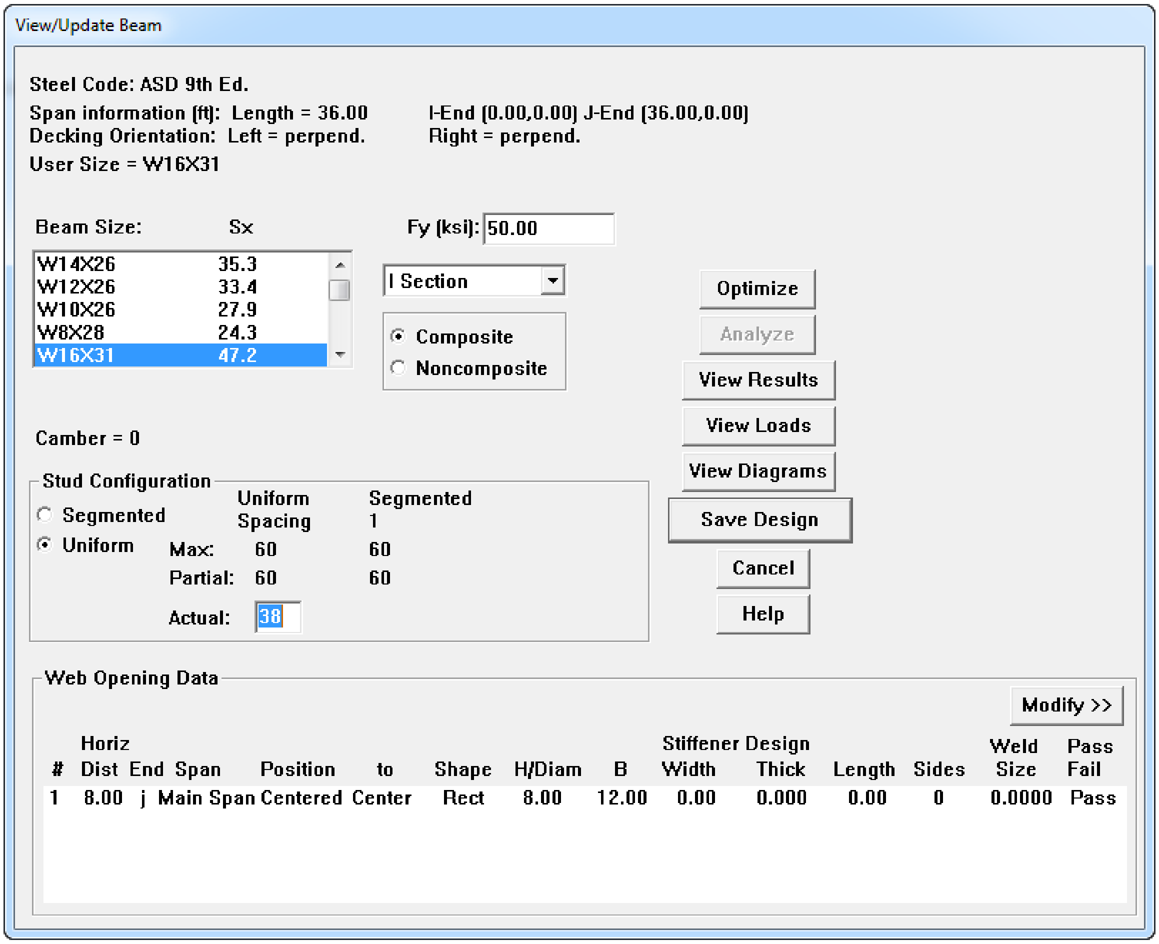
Process menu item	Description	Shortcut
Beam Design...	Designs the beam and opens either the View/Update Beam dialog or the Smartbeam View Update dialog .	CTRL+D
Clear Design	Used to clear the current beam design.	
Freeze Design	Used to save (freeze) the current beam design. The program will then treat the size as a user-assigned size.	

6.5.1 View/Update Beam dialog

Displays the present beam design, optimized or user-specified, and allows you to investigate other designs.

New designs can be saved or discarded. The header contains information about the beam you are viewing including: the building code being used the beam number, the span length, the beam coordinates and the deck orientation relative to the beam. The yield strength value and composite flag used in the design are displayed.

Figure 6-4: The View/Update Beam dialog



Opens when **Process** > **Beam Design** is selected for a steel beam.

For beams that DO NOT have a user-assigned size or a user-specified design, the optimized beam size is highlighted in the Beam Size box. If the beam was designed compositely, the optimized stud configuration is also displayed.

For beams that have user-specified design from a previously executed View/Update command, the user-specified design will be displayed.

Dialog Controls

Beam Size list
Contains a list of all beam sections contained in the Design Steel Table .

Fy
Used to specify a yield strength for the steel material.

section type
Select the profile type (i.e., I Section, Rectangular hollow section, or channel) from the drop down list by click the down arrow.

composite flag

Select to use a composite or non-composite floor system with the current beam selection. This is useful if an otherwise composite beam should also be analyzed as non-composite (i.e., in negative moment, cracked concrete, etc.).

> **Note:** The Composite option may be disabled, indicating that the beam is unable to be designed as a composite beam due to the deck configuration or by the user designating the beam as non composite. In this case, modify the data in the Span Definition dialog and/or the Composite dialog .

Stud Configuration

If the beam is composite (i.e., the composite flag is set to the Composite option), the stud configuration will be shown for both Segmented and Uniform Stud Distribution. RAM SBeam automatically designs the beam partially composite. You may update the stud design by changing between uniform and segmented, or by entering the actual number of studs to be used in the table cells.

Web Opening Data

Displays the openings currently specified for the steel beam. Openings in the webs of I-shaped steel beams can be specified in the Layout Web Openings dialog . During optimization or analysis of the beam, the effects of the web openings on the beam are considered. If necessary, the program will design stiffeners above and below the openings. The criteria for the stiffeners can be specified in the Web Opening Criteria dialog .

When an opening has been assigned to a beam, the opening information and stiffener design is shown in the View/Update dialog. That information includes the location of the opening (measured along the horizontal projection), the span end from which the distance is measured, the span in which the opening occurs (Left Cantilever, MidSpan, or Right Cantilever), the position within the depth of the web (e.g., Centered, distance from top of beam to top of opening, etc.), shape (Rectangular or Circular), and height H and width B of a rectangular opening or Diameter of a circular opening. The Stiffener Design data includes the width, thickness and length of the stiffener plates, the number of sides on which they occur, and the weld size (full length, both sides of each stiffener). If the opening or stiffeners fail any design requirements, “Fail” is indicated.

> **Note:** When stiffeners are used, they are in pairs, one stiffener plate above and one below the opening; both stiffener plates are the same size. They may occur on one side of the beam web or both sides of the beam web. Often, no stiffeners are required.

Modify >>

Opens the Modify Web Opening dialog , which is used to edit the web opening data or stiffener design.

Optimize

Causes the automated design of the beam using the newly selected yield strength, composite flag, and/or other design criteria.

When the Optimize button is clicked, the beam is optimized and sized to satisfy the requirements of the web openings, and the need for stiffeners is determined and the size optimized accordingly. Any modifications to the opening geometry made in the Modify Web Openings dialog will be used, but any modifications to the stiffener data will be discarded (and the stiffeners will be optimized).

Analyze

Causes the stress/capacity criteria, web opening, and deflection criteria checks to be run on the selected beam. If the member fails any check, a message will appear warning you of the failure.

When the Analyze is clicked, the beam will be checked for the current web opening information, and design warnings given if the web openings fail for any reason. The stiffeners will be optimized as required, unless the stiffener data has been modified using the Modify Web Openings dialog, in which case the current stiffener data will be checked and design warnings given if the stiffeners fail.

View Results

Opens the Beam Design report which is used to view a full report for the design of the beam. You may scroll through this Window to observe the actual design of the member based on the currently selected parameters. Closing the report will return control to the View/Update dialog. This report can also be viewed by selecting **Reports** > **Beam Design**.

View Loads

Opens the Loads Diagram window, which is used to

View Diagrams

Opens the Shear, Moment, and Deflection Diagrams window, which is used to view diagrams of the internal beam forces.

Save Design

Used to save a new design back to the database. If a beam design was selected using the **Optimize** tool, then this design will be saved and marked as a user-defined size. If the new beam was manually selected and the **Analyze** tool was used, the design will be saved and marked as a user-assigned size. This design will remain until it is removed by selecting **Process** > **Clear Design** or a new design is saved in this dialog.

When the Save Design button is clicked, the opening and stiffener designs are saved to file, including any changes made in the Modify Web Openings dialog.

Cancel

Closes the dialog without saving any changes made to the beam design since the last time the **Save Design** button was clicked.

Help

Opens the RAM SBeam help window.

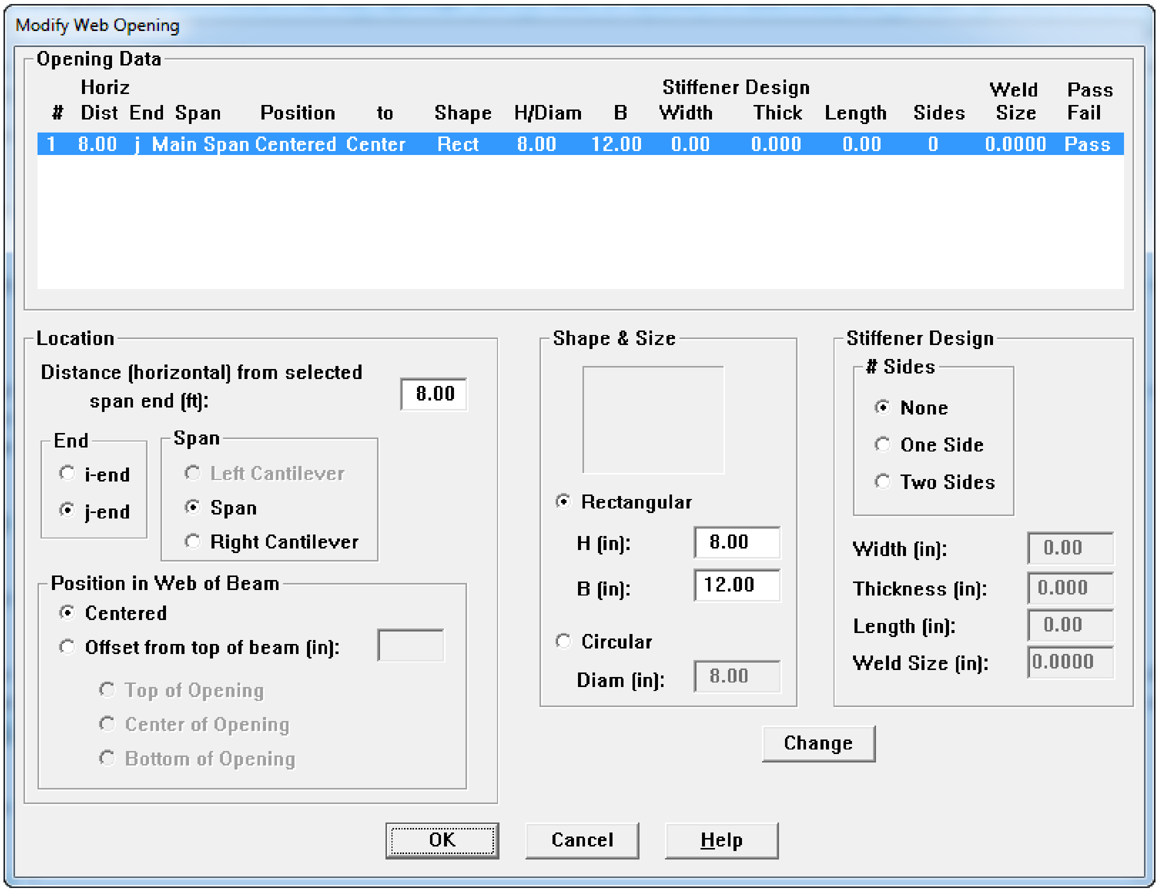
6.5.2 Modify Web Opening dialog

Used to edit the web opening data or stiffener design for openings already added to the steel beam.

Openings in the webs of I-shaped steel beams can be specified in the Layout Web Openings

dialog . During optimization or analysis of the beam, the effects of the web openings on the beam are considered. If necessary, the program will design stiffeners above and below the openings. The criteria for the stiffeners can be specified in the Web Opening Criteria dialog .

Figure 6-5: The Modify Web Opening dialog



Opens when the **Modify** >> button is clicked in the View/Update Beam dialog.

Dialog Controls

Opening Data table

Displays the openings currently specified for the steel beam. Openings in the webs of I-shaped steel beams can be specified in the Layout Web Openings dialog . During optimization or analysis of the beam, the effects of the web openings on the beam are considered. If necessary, the program will design stiffeners above and below the openings. The criteria for the stiffeners can be specified in the Web Opening Criteria dialog .

When an opening has been assigned to a beam, the opening information and stiffener design is shown in the View/Update dialog. That information includes the location of the opening (measured along the horizontal projection), the span end from which the

distance is measured, the span in which the opening occurs (Left Cantilever, MidSpan, or Right Cantilever), the position within the depth of the web (e.g., Centered, distance from top of beam to top of opening, etc.), shape (Rectangular or Circular), and height H and width B of a rectangular opening or Diameter of a circular opening. The Stiffener Design data includes the width, thickness and length of the stiffener plates, the number of sides on which they occur, and the weld size (full length, both sides of each stiffener). If the opening or stiffeners fail any design requirements, “Fail” is indicated.

> **Note:** When stiffeners are used, they are in pairs, one stiffener plate above and one below the opening; both stiffener plates are the same size. They may occur on one side of the beam web or both sides of the beam web. Often, no stiffeners are required.

Distance (horizontal) from selected span end

This is the distance in current units from the selected **End** of the selected **Span**.

End

Select the end of the span from which the distance to the center of the opening is measured.

Span

Select the beam span in which the opening is located. Only those spans which have been specified in the [Span Definition dialog](#) are active.

Position in Web of Beam

Specify the location of the web opening within the depth of the beam web. Select either the **Centered** or **Offset from top of beam** option. For the latter option, specify the length of the offset and to which point on the opening the offset is measured (i.e., top, center, or bottom).

Shape And Size

Specify the general shape type of the web opening (i.e., Rectangular or Circular) as well as the dimensions for the selected shape. The diagram displays the nomenclature for the selected shape type.

Stiffener Design: # Sides

Select the stiffener arrangement to use for the selected web opening. Stiffeners placed on only one side of the web are often acceptable and more economical. They are not always desirable, however, because they cause the beam to be asymmetrical (which can be a problem in cases of long unbraced lengths). The program will investigate the design of web openings with stiffeners on one side of the web if that option is selected, otherwise it will not.

> **Note:** It may be more economical to use deeper, heavier beams rather than adding stiffeners. If neither option to allow stiffeners is selected, the program will optimize to the beam size that does not require stiffeners at the openings. On the other hand, if depth of beams is a concern, lighter, shallower beams may be acceptable if stiffeners are allowed.

The dimensions of the stiffeners selected (if the program determined they are required for the current design) are displayed below. These values may not be edited. The incremental values used in stiffener size selection are specified in the

Web Opening Criteria dialog .

Change

Updates the selected opening in the Opening Data table with any changes made in this dialog.

OK

Accepts the changes made by clicking the Change button for any openings which have been edited in the dialog.

Cancel

Closes the dialog without saving any changes made.

Help

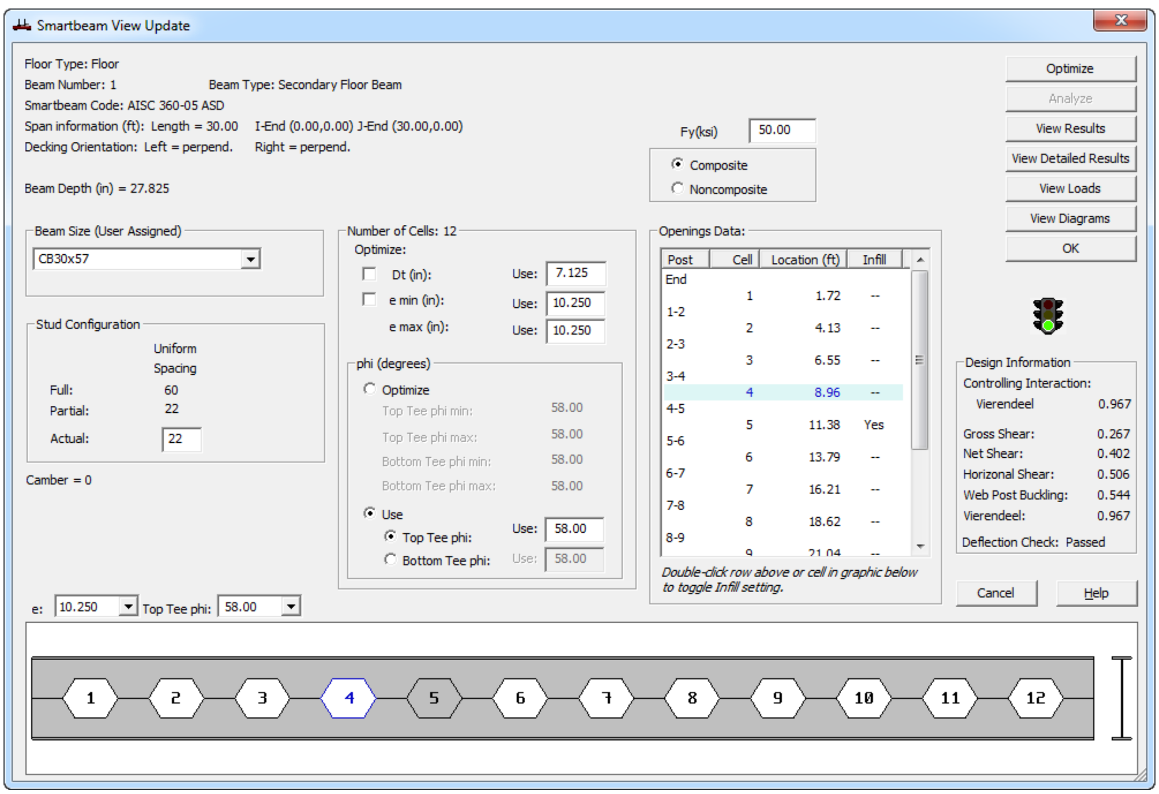
Opens the RAM SBeam help window.

6.5.3 Smartbeam View Update dialog

Used to review and edit the design of Smartbeams.

The Smartbeam View Update dialog works similarly for Smartbeam design as for Steel beam design. The design of individual members can be viewed, altered, and saved.

Figure 6-6: Smartbeam View Update dialog



Opens when **Process** > **Beam Design** is selected for a Smartbeam.

When a beam with an assigned size is selected, the assigned size is shown highlighted in the Beam Size list. The values assigned for DT, e and phi or Do and S are also shown. The Optimize check boxes for DT, e and phi or Do and S are also checked. To investigate alternate

DT, e and phi or Do and S, clear the respective Optimize check box and edit the corresponding edit fields. The Optimize and Analyze commands respect the state of the Optimize checkboxes when invoked. A cleared Optimize checkbox against DT, e or phi or Do or S makes the parameter user-assigned. For Castellated beams, the user may assign a Top or Bottom tee phi by first clearing the phi Optimize checkbox and selecting either the Top or Bottom phi radio button.

> **Note:** The Analyze command investigates the current beam size selection while enforcing the state of the Optimize checkboxes while the Optimize command enforces the state of the Optimize checkboxes but disregards the current beam size selection.

When a new size is selected from the Beam Size list and an Analyze performed, values of DT or Do and ranges for e or S and phi are inserted into the DT, e and phi (or Do and S) edit boxes, respectively. Those values are either the optimized values or user-specified values, depending on the state of the corresponding check boxes.

The critical configuration or configuration of DT, e and phi (or Do and S) with the worst interaction value (controlling interaction) is displayed at the bottom of the dialog. Alternate beam configurations corresponding to the minimum, maximum or controlling e (or S) and phi may be viewed by selecting any of the listed e (or S) or phi values from the combo boxes immediately above the graphic.

The interaction values for all design checks performed are also shown along with a traffic light graphic representing the state of the current design (red = failing, yellow = unchecked, and green = passing).

Dialog Controls

Beam Size

Contains a list of all beam sections contained in the Design Steel Table . When the program optimized beam size is selected, the word Optimized is displayed here. Otherwise, the word User Assigned is displayed (e.g., for a Frozen design). When a beam with no assigned size is selected, the optimized size is shown highlighted in the Beam Size list.

Stud Configuration

If the beam is composite (i.e., the composite flag is set to the Composite option), the stud configuration will be shown for both Segmented and Uniform Stud Distribution. RAM SBeam automatically designs the beam partially composite. You may update the stud design by changing between uniform and segmented, or by entering the actual number of studs to be used in the table cells.

e

(For castellated beams) Select either the specified minimum or maximum value of e as determined by the program or that you have specific.

Top Tee phi

(For castellated beams) The range of phi values for the Top and Bottom tees are shown. Phi ranging from 58 to 62 degrees is always investigated. For asymmetric Castellated beams, the range for the Top and Bottom tees differ but fall in the range from 58 to 62 degrees.

Since e and phi affect the spacing of the holes, the range of acceptable e and phi values allow the manufacturer to space the openings as necessary to facilitate the connections at the ends of the beam.

S

(For cellular beams) Select an option for the hole spacing for the current beam design from the acceptable range values listed. The beam elevation diagram and Openings Data table update accordingly.

Dt

(For castellated beams) Depth of the tee section above and below the opening. The optimum value for DT is displayed here when the Optimize option is selected. Clear this option to specify your own value for Dt.

e min/max

(For castellated beams) The range of acceptable e values, emax and emin, are listed when the Optimize option is selected.

phi

(For castellated beams) The angle between the centerline of the beam and the sloped portion of the opening.

Diameter

(For cellular beams) The optimum diameter of the web holes is displayed here when the Optimize option is selected. Clear this option to specify your own value for Diameter.

Fy

Used to specify a yield strength for the steel material.

composite flag

Select to use a composite or non-composite floor system with the current beam selection. This is useful if an otherwise composite beam should also be analyzed as non-composite (i.e., in negative moment, cracked concrete, etc.).

> **Note:** The Composite option may be disabled, indicating that the beam is unable to be designed as a composite beam due to the deck configuration or by the user designating the beam as non composite. In this case, modify the data in the Span Definition dialog and/or the Composite dialog .

Opening Data

The Openings Data lists the locations of posts and openings and the controlling post or opening is highlighted in blue. Similarly, the controlling post or opening in the beam configuration diagram at the bottom of the dialog is also highlighted. When an analyzed user-specified configuration fails, the failing post or cell is highlighted in red.

Optimize

Causes the automated design of the beam using the newly selected yield strength, composite flag, and/or other design criteria. The Optimize process respect the state of the Optimize checkboxes when invoked.

Analyze

Causes the stress/capacity criteria, web opening, and deflection criteria checks to be run on the selected beam. If the member fails any check, a message will appear in the Design Information panel warning you of the failure and the traffic light will display red. The Analyze process respect the state of the Optimize checkboxes when invoked.

View Results
Opens the Beam Design report which is used to view a full report for the design of the beam. You may scroll through this Window to observe the actual design of the member based on the currently selected parameters. Closing the report will return control to the View/Update Beam dialog box. This report can also be viewed by selecting **Reports** > **Beam Design**.

View Detailed Results
Used to open a more detailed version of the Design Results Report.

View Loads
Opens the Loads Diagram window, which is used to

View Diagrams
Opens the Shear, Moment, and Deflection Diagrams window, which is used to view diagrams of the internal beam forces.

OK
Saves any size, opening, and stud configuration changes made and closes the dialog.

Cancel
Closes the dialog without saving any changes made to the beam design since the last time the Save Design button was clicked.

Help
Opens the RAM SBeam help window.

6.6 Reports menu

Contains items for selecting the destination for reports, changing report preferences, and displaying reports.

Table 6-6: Report menu items

Report menu item	Description	Shortcut
Printer	Selecting this option sends the report directly to the printer.	
Screen	Selecting this option displays the report on screen. Sets the destination for reports as the Report Viewer window .	
Text File	Selecting this option to save the report in a comma delimited text file. The resulting unformatted, comma-delimited file (`.csv`) is suitable for opening in a text editor or Microsoft Office Excel® or other spreadsheet programs.	
Viewer File	Saves the report to a report viewer file. This provides the ability to view the report outside of RAM SBeam. The resulting file (Virtual	

Report menu item	Description	Shortcut
	Print Engine file format, `.vpe`) can be opened with the report viewer program, `VPEView.exe`, which is distributed with the program and installed in the `Prog` directory with the other program executables. This is convenient for electronically transmitting the reports.	
Report Preferences...	Opens the Report Preferences dialog, which is used to change report options, including text styles for various parts of the report.	
Beam Design	Opens the beam design report, which consists of one or more pages of output, detailing span information, beam properties, beam loading, and calculations for shear, moment, reactions and deflections.	
Load Diagram	Sends the load diagram to the selected destination on the Reports menu.	

6.6.1 Report Preferences dialog

Used to change report options, including text styles for various parts of the report.

This command opens the Report Styles dialog box in order to change the report options. The defaults styles that are shipped with RAM SBeam have been selected for optimal viewing of the reports. Making the margins smaller or the font much bigger may cause the text in a table to wrap to the next line. If this happens, selecting a smaller font for the Body section of the reports and rerunning the reports should correct the problem.

Margins

Set the top, bottom, left and right margins for the pages of the reports.

Paper Size

Select either a pre-defined paper size, or select Custom Size and specify the page width and height.

Text Styles

Each rich text format report contains four different styles of text: Title, Header, Section Headings, and Body. The user can specify font name, font size, color, bolding, underlining, etc., for each of the four different text styles. To change the text for one of the text styles, click the button to the left of the text box. Make any desired changes in the standard Font dialog box and click OK. Changes will be reflected in the corresponding text box.

Default Destination

There are four options for the default destination of the reports. For the default destination, select one of the following:

- Screen – reports are previewed on the screen in a non-editable viewer. The viewer has toolbar buttons that allow printing, zooming in and out, navigating through the pages of the report, and closing the preview.
- Printer – reports are sent directly to the printer without previewing.
- Text File – report information is sent to a file. The user can choose between a simple text file (.txt) or a comma-separated value files (.csv). This is the only option that does not use the other user selected report styles. One font is used for all sections of the report and all formatting is removed. However, commas are in place to separate table columns so that the file can be imported into a spreadsheet program.
- Viewer File – reports are saved to the Virtual Print Engine file format (file extenstion `.vpe`). These files can only be opened with `Vpeview.exe`, which is distributed with the RAM SBeam and installed in the same directory as the program executables. This format allows reports to be saved and later viewed on-screen outside RAM SBeam.

Company Logo

A company logo can be included in the upper left-hand corner of each page of the reports if this option is selected. The logo to be included must be named logo.bmp or logo.jpg and placed in the same directory as the RAM SBeam program executable. The RAM logo is distributed with the program and can be replaced as needed. The size of the bitmap is irrelevant as it will be scaled appropriately.

OK

Closes the dialog and updates any changes made.

Cancel

Closes the dialog without saving any changes.

Help

Opens the RAM SBeam Help window to a related help topic.

6.7 View menu

Contains tools used to manipulate the graphical display in the View window.

Table 6-7: View menu items

View menu item	Description	Shortcut
Brace Points	Toggles the display of flange braces in the graphical display.	
Web Openings	Toggles the display of the web openings and stiffeners on the beam.	
Loads	Toggles the display of the load diagrams on the graphical display.	

View menu item	Description	Shortcut
Rotate to P erspective	Orients the beam in the View window to a perspective view.	
Rotate to Profile	Orients the beam in the View window to a profile view.	
Zoom In	Used to increase the View window's magnification.	
Zoom Out	Used to decrease the View window's magnification.	
Toolbar	Toggles the display the of the See "Toolbar" on page 8, which contains commonly used tools..	
Status Bar	Toggles the display of the window status bar.	

6.8 Help menu

Contains resources for getting assistance on using the program.

Table 6-8: Help menu items

Help menu item	Description	Shortcut
Help Topics	Opens the RAM SBeam help window. **Tip:** Context -sensitive Help is available by selecting the Help command in each dialog.	F1
M anual	Opens the RAM SBeam manual. A program capable of reading .Portable Document Format files (file extension `.pdf`) is required, such as Adobe Acrobat Reader®. **Tip:** The Manual is in a file called `RAMSBeam.pdf`, located in the Prog subdirectory.	
About RAM SBeam	Opens the program About dialog, which contains version and copyright information for the program.	

Chapter 7
Keyboard Shortcuts

Shortcut keys for menu commands are indicated in the menus. All menus, menu items, and dialog box controls are accessible by pressing the Alt key and the underlined letter (also called an access key or mnemonic) associated with that control.

7.1 Working with Beam Files

Table 7-1: Controlling the Graphical Display

Action	Shortcut
Create a new file.	CTRL+N
Open an existing file.	CTRL+O
Open a file from the recently opened list.	ALT+F+corresponding number key
Save the current file.	CTRL+S
Print the contents of the View window.	CTRL+P
Perform a beam design.	CTRL+D
Exit the program.	ALT+F4

7.2 Working with Dialogs

Table 7-2: Managing Data in a Dialog

Action	Description	Shortcut
Select the contents of a data field.		Double-click (right mouse button)
Move the input focus to the next field.		TAB
Move the input focus to the previous field.		SHIFT+TAB
Move between dialog tabs	In dialogs with multiple tabbed pages, you can press the TAB key until the current tab is highlighted (with a dashed line around the tab name) and then move between tabs using the arrow keys.	Left or Right arrow keys
Select items in a drop-down list.		Up or Down arrow keys
Select different items in a radio button list.		Arrow keys
Select a option (check box).		Space bar
Save and close a dialog box.	Pressing the Enter key effectively selects the currently highlighted button in the dialog, which defaults to the **OK** button. If you TAB or SHIFT+TAB to a different button (highlighted with a dashed line), then this button will be selected upon pressing the Enter key.	Enter

Action	Description	Shortcut
Close the dialog without saving any changes.		ESC (Escape)
Get help on a dialog.	Same effect as selecting the **Help** button.	F1

7.3 Copy, Paste and Delete

Some dialog boxes (most notably the Uniform, Trapezoidal and Concentrated load tabs in Loads – Load Cases) feature a spreadsheet-like interface. In these spreadsheets, several common keyboard commands are available.

Table 7-3: Inserting, Deleting, and Moving Data

Action	Description	Shortcut
Copy	Copy data in a cell or group of cells to the clipboard (select those cells by clicking and dragging the cursor across them) or copy data in an entire line of cells (select the row by clicking on the left-most cell or the column).	CTRL+C
Paste	Insert data copied from a cell or group of cells (select the first cell into which that data is to be copied) or paste data copied from an entire line of cells (select the row by clicking on the left-most cell or the column by clicking on the top-most cell).	CTRL+V
Cut	Copy selected data and then Delete from selected location.	CTRL+X
Delete	Delete the selected data. Same selection procedure as Copy applies.	DEL (Delete)

Note: Multiple adjacent rows can be selected either by clicking on the first cell of the first row and dragging the cursor to the first cell of the last row, or by clicking on the first cell of the first row and while holding down the Shift key selecting the first cell of the last row. Multiple columns can similarly be selected. Note that nonadjacent rows or columns can be similarly selected using the Control key, rather than the Shift key.

7.4 View Window

Table 7-4: Controlling the Graphical Display

Action	Description	Shortcut
Rotate the beam left or right.	Rotates the beam about a vertical axis passing through the depth of the member.	Left or Right arrow keys
Rotate the beam up or down.	Rotates the beam about a horizontal axis passing through the thickness of the web.	Up or Down arrow keys
Pan Left or Right	Pans the view of the beam horizontally	SHIFT+Left or SHIFT+Right arrow keys
Pan Up or Down	Pans the view of the beam vertically	SHIFT+Up or SHIFT+Down arrow keys

Chapter 8

Technical Notes

Contains explanations of the assumptions and methodology used by RAM SBeam.

In the design of a structure a great number of decisions must be made. What is acceptable to one engineer may not be acceptable to another. It is crucial that you understand the decisions and assumptions being made by the RAM SBeam program. If these are not appropriate for the specific conditions of a particular building, you should augment or replace the results from RAM SBeam with those of some other tool.

Every effort has been made to include a discussion of significant decisions and assumptions made by the program. Generally, if there is any question as to how the RAM SBeam handles any particular condition, a beam can be quickly entered and analyzed, and the results verified with the appropriate hand calculations.

8.1 Steel Design Codes for Steel Beams

RAM SBeam incorporates the requirements of several U.S. and international steel design specifications.

These specifications include:

- "*Specification for Structural Steel Buildings - (March 9, 2005)*", ANSI/AISC 360-05 ASD (Allowable Strength Design) and ANSI/AISC 360-05 LRFD (Load Resistance Factored Design) published by the American Institute of Steel Construction in Manual of Steel Construction (13th Edition).
- "*Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design (June 1, 1989)*", published by the American Institute of Steel Construction in Manual of Steel Construction - Allowable Stress Design (9th Edition). The requirements of Supplement No. 1 (December 17, 2001) are also included as an option.

- "*Load and Resistance Factor Design Specification for Structural Steel Buildings (December 1, 1993)*", published by the American Institute of Steel Construction in Manual of Steel Construction - Load and Resistance Factor Design (3rd Edition).
- "*Limit States Design of Steel Structures*", CAN/CSA-S16-01, published by the Canadian Institute of Steel Construction. S16S1-05 Supplement No. 1 is also implemented.
- "*Structural use of steelwork in building*", BS 5950 : Part 1, "Code of practice for design in simple and continuous construction: hot rolled sections" (1990), published by the British Standards Institute.
- "*Structural use of steelwork in building*", BS 5950 : Part 1, "Code of practice for design: rolled and welded sections" (2000), published by the British Standards Institute.
- "*Structural use of steelwork in building*", BS 5950 : Part 3, Section 3.1, "Code of practice for design of simple and continuous composite beams" (1990), published by the British Standards Institute.
- "*Eurocode 3 - Design of Steel Structures, BS EN 1993-1-1:2005*", published by the European Committee for Standardization in Design of Steel Structures (Eurocode 3).
- "*Eurocode 4 - Design of Composite Steel and Concrete Structures, EN 1994-1-1:2004*", published by the European Committee for Standardization in Design of Composite Steel and Concrete Structures (Eurocode 4).

In the RAM SBeam program, its outputs, and throughout the remainder of this manual, these are referred to as AISC 360 ASD, AISC 360 LRFD, ASD, LRFD, CAN/CSA-S16-01, BS 5950, and Eurocode respectively.

8.2 Member Loads

Includes a description of the load types which are used in the program, load conventions, and how the program handles skip loading.

8.2.1 Load Properties

A load consists of a Dead Load, a Construction Dead Load, a Live Load and a Construction Live Load.

> **Note:** Regarding terminology: Repeated reference is made throughout the program and the documentation to "Live Loads". In some codes these loads are referred to as "Imposed Loads".

Dead Load

The total dead load such as slab, deck, partitions, miscellaneous, etc. It should include slab self-weight, as the program does not include this automatically. The beam self-weight will be automatically included if that option is selected on the Load Cases dialog Uniform Load tab .

Construction Dead Load

Also referred to as the Pre-composite Dead Load, is a temporary condition load and is that portion of the Dead Load that is applied to the beam prior to composite action. It must be less than or equal to the Dead Load. This value is only used when designing unshored ("unpropped") composite beams and need not be specified for non-

composite beams or shored ("propped") composite beams. This is in addition to the Construction Live Load described below.

Live Load

The total live load appropriate for the particular building based on the applicable Building Code and use of the building. Live Loads should be reduced for Live Load Reduction if applicable; the program does not perform any Live Load Reduction.

Construction Live Load

A temporary load that is applied to the beam prior to composite action. It represents the temporary load due to workers and equipment on the bare beam prior to composite action. This load is combined with the Construction Dead Load when investigating the pre-composite beam. Its magnitude is independent of the Live Load value. This value is used only when designing unshored ("unpropped") composite beams and need not be specified for non-composite beams or shored ("propped") composite beams.

8.2.2 Positive Loads, Negative Loads, and Skip Loading

Load conventions used in the program and skip load patterns.

On the output, loads are referred to as Positive or Negative. A Positive load is a downward acting load while a Negative load is an upward acting load. The program keeps track of Positive and Negative loads independently.

On the output, moments and reactions are labeled Maximum Positive and Maximum Negative. If there is no Negative value, it is listed as 0.0 or not shown at all. If there is no Positive value, it is listed as 0.0 or not shown.

As required by some Codes, when a beam is cantilevered at one or both ends the program skip loads the Live load on adjacent spans and alternating spans such as to create the maximum moments, deflections, and reactions. Not only does the program skip load the Live loads, it applies the Positive and Negative loads on alternating spans such that the worst conditions are calculated. Note that the Live loads are skip loaded regardless of the Code selected.

The following skip load condition is performed to calculate the maximum positive moment (top flange in compression):

- Negative Live Loads on Cantilevers and Positive Live Loads on Span

The following skip load condition is performed to calculate the maximum negative moment (bottom flange in compression):

- Positive Live Loads on Cantilevers and Negative Live Loads on Span

The following skip load conditions are performed to calculate the maximum shear force:

- Positive Live Loads on Left Cantilever, and Negative Live Loads on Span and Right Cantilever
- Positive Live Loads on Left Cantilever and Span, and Negative Live Loads on Right Cantilever
- Negative Live Loads on Left Cantilever, and Positive Live Loads on Span and Right Cantilever

- Negative Live Loads on Left Cantilever and Span, and Positive Live Loads on Right Cantilever

If there are no Negative Live Loads, a value of 0.0 is applied to the particular cantilever or span in the above conditions. Similarly for Positive Live Loads.

The Construction Live Load is similarly skip loaded.

Dead Load is not skip loaded; the full dead load is applied to all spans and cantilevers.

Where BS 5950 and Eurocode require the investigation of the interaction of moment and shear effects, each unbraced segment of the beam is checked for the maximum shear (with associated moment) and the maximum moment (with associated shear) using the skip loading conditions which produce the maximum moment, and for the maximum shear (with associated moment) using the skip loading conditions which produce the maximum shear.

8.3 Composite Beam Design

Methodoly used for the design of composite beams.

8.3.1 Calculating Effective Flange Width

The effective flange width is automatically calculated for the specified Code based on the distance to edge or adjacent beam specified in the Composite dialog Decking tab.

When calculating the effective flange width for BS 5950 for a simple beam with a cantilever, $L_z = L_3 - 0.3L_4$, but $L_z \geq 0.7L_3$ (see Figure 3 therein). When the slab spans at an angle with respect to the beam, b_e is based on an interpolation which is a function of $\sin^2\theta$ and the values from Clause 4.6(a) and Clause 4.6(b).

When calculating the effective flange width for the Eurocode for a simple beam with a cantilever, $L_e = 0.85\ L$ when there is cantilever on only one end, and $L_e = 0.7\ L$ when there is a cantilever on both ends (see Figure 5.1 in EC4).

8.3.2 Deck Orientation

The orientation of the deck relative to the beam is an important consideration in composite design.

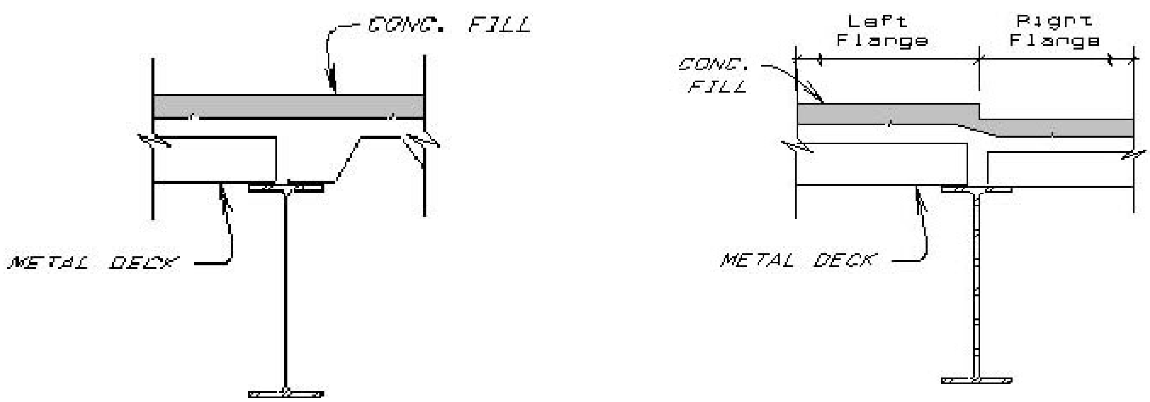
There are special Code requirements for deck perpendicular to the member versus parallel to the member. Based on the angle values specified in the Composite dialog Decking tab, the program applies the appropriate provisions. If the orientation is within ten degrees of being parallel, the program assumes that the orientation is parallel. In ASD design, when the deck is parallel to the beam, the concrete within the deck flutes is used in calculating the total horizontal shear, Vh, and the composite section properties, Itr and Str (the Ad^2 term is used but the Ixx term, the moment of inertia of the concrete in the flute around its own centroid, is ignored). If the angle between the beam and the deck orientation is greater than ten degrees the concrete within the flutes is ignored. In all other Codes, the concrete within the flutes is ignored in all cases.

8.3.3 Effect of Slab and Deck Change

How the program accounts for deck orientation change at the beam.

Generally a beam will only carry one type of deck with a single orientation. However, occasionally the slab properties, deck properties, and/or deck orientation change along a beam. This change can occur either down the axis of the beam (see the figure below) or else at some point along the beam. The Codes do not specifically address these situations. RAM SBeam Design conforms to rules outlined in the following sections.

Figure 8-1: Change in deck orientation



Change in Deck Orientation

When the orientation of the deck is different on one side of the beam than the other, for the purpose of calculating the allowable shear values for the studs the deck is considered to be oriented in the direction of the deck that is non-parallel to the beam. This is conservative.

If the deck on either side is parallel to the beam, the number of studs allowable in a single row along the beam will be limited to:

L / (6 * StudDiam)

per I3.2d(6) of AISC 360-05, I4 of AISC ASD 9th Edition or I5.6 of AISC LRFD 3rd Edition or Clause 17.7.2.4 of CAN/CSA-S16-01, or

L / (5 * StudDiam)

per Clause 6.6.5.7(4) of Eurocode 4 or Clause 5.4.8.4.1 of BS 5950, where L is the Span length, and StudDiam is the nominal stud diameter.

If the deck on either side is perpendicular to the beam, the maximum stud spacing will be limited to that permitted by the specified Code.

Change in Slab Properties

When the properties of the slab are different on one side of the beam than the other, the section properties of the composite section are calculated using the different slab properties for

each side.

8.3.4 Shear Stud Connectors

Process used by the program to determine the required number of shear stud connectors .

The program calculates the number of studs required, accounting for the locations of maximum moments and zero moments and special distributions required due to the presence of concentrated, or point, loads. It calculates the studs required for a uniform distribution along the entire length of the beam as well as for a segmented distribution where the segments are defined by the locations of the point loads. If there are no point loads on a member there will only be one segment. In this case the number of studs required for "segmented" distribution and "uniform" distribution will be identical. When determining the number of studs required for a uniform distribution, the highest stud density required in any segment is determined and then placed along the full beam length.

The program automatically defaults to a uniform distribution of studs unless fewer total studs are required by using the segmented distribution.

If there are more than four point loads, the program always defaults to uniform stud distribution.

Segments are determined based on the location of the point loads. If a segment is so short that no studs could be placed within it, it is combined with the adjacent segment.

If the point of maximum moment occurs at a point other than at the location of a point load, the number of studs in that segment is based on the greater of the densities required on either side of the maximum moment. This is also the case for beams with no point loads.

If the point of zero moment occurs at a point other than the support, the number of studs between the support and the point of zero moment is based on the density of studs required in the segment adjacent to the point of zero moment.

The point of zero moment used is that which corresponds to the load combination that produced the maximum moment.

For AISC 360-05, LRFD 3rd, Eurocode, CAN/CSA-S16-01, or BS 5950, when calculating the studs required between any concentrated load and the point of zero moment, a more exact approach is incorporated whereby the number of studs is based on that required to generate the moment capacity necessary to satisfy the actual design moment at the point of the concentrated load. This is done in lieu of the more simplified approach of calculating the studs based on ratios of the moments allowed by some codes.

Cantilevers are not considered as a segment nor are studs called out on cantilevers since the concrete on a cantilever is generally not in compression. Even when there is an uplift load at the end of the cantilever resulting in compression in the concrete on the cantilever, the cantilever beam is not designed as a composite section.

In the View/Update dialog , you can change the number of studs in each segment. When the program does an analysis using the user-specified studs, it only checks the composite section against the maximum moment; it does not check for adequate number of studs at

each point load. In other words, when optimizing the size and studs the program ascertains that the stud requirements at each point load, in addition to the point of maximum moment, are satisfied, but when analyzing a user-specified size and stud configuration the program only checks to determine if the stud requirements are met at the point of maximum moment. Thus you may, without getting an explicit warning, specify a distribution of studs that satisfies the requirements for the maximum moment but does not satisfy the additional requirements for the stud distribution due to point loads. However, the lack of adequate studs will be apparent by comparing the number of studs indicated as required for partial composite ('Partial") with the number of studs that you specify ("Actual"). The number of studs specified should always equal or exceed the number of studs that the program shows for Partial. These values are shown in both the View/Update dialog box as well as the Beam Design output.

The program indicates the number of studs required for full composite action as well as minimum partial composite action. The number of studs shown for Partial composite action represents the greater of the number required for moment capacity at points of maximum moment and point loads, minimum percent of full composite, or maximum allowable stud spacing. If the number of studs required to produce full composite action exceeds the maximum number of studs that can be placed along the beam, the values shown for full composite are limited to that maximum number, and the output will indicate "Max" rather than "Full". This is based on the minimum stud spacing for deck parallel to the beam, and three studs per flute otherwise. If the number of studs that you specify exceeds the number shown for full composite, the additional studs are ignored. Additionally, the number of studs shown for full composite does not reflect minimum stud requirements, while the number of studs shown for partial composite does. Thus it is possible in some cases for the number of studs shown for partial composite to exceed the number of studs shown for full composite. An example of this is a girder loaded with equal loads at the third points; RAM SBeam will indicate that no studs are required in the middle segment for full composite but that some (minimum studs) are required for partial composite. It should be noted that consistent with the Code requirements, in calculating the properties Seff and Ieff of partially composite beams the value of Cf (for AISC 360-05 ASD, AISC 360-05 LRFD and LRFD 3rd) or Vh (for ASD 9th) is the total horizontal shear from the appropriate equations and is not the value limited by the number of studs that can be placed.

There is a provision in the AISC Codes which states, "Unless located directly over the web, the diameter of studs shall not be greater than 2-1/2 times the thickness of the flange to which they are welded." The other codes have a similar provision. The program checks this provision before selecting a member size requiring multiple rows of studs. If the provision is not met, the program will select a larger size. In the case of CAN/CSA-S16-01, the program will not select a beam whose flange thickness is less than 2-1/2 times the stud diameter.

There is a provision in the AISC Codes which states, "The minimum center-to-center spacing of stud connectors shall be … 4 diameters transverse to the longitudinal axis of the supporting composite beam." The other codes have a similar provision. The program checks this provision when it specifies multiple rows of studs to determine if the beam width is adequate for the given number of rows. If not, a larger size will be selected.

Composite decks can be specified as formed steel deck (profiled steel sheeting) of a particular brand, or they can be specified as flat slab. If specified as flat slab, the stud spacing is not

impacted by flute spacing, and the allow stud shear capacity is not multiplied by the reduction factors applicable to studs in formed steel decks.

You can limit the allowable shear in each stud by specifying a smaller value of Fu for the studs in the Composite dialog . The program limits the stud shear capacity to $R_g R_p A_{sc} F_u$ for AISC 360-05 (ASD and LRFD), $A_{sc} F_u$ for LRFD, 0.5AscFu for ASD, $\phi_{sc} A_{sc} F_u$ for CAN/CSA-S16-01, and $0.8A_{sc} F_u/\gamma v$ for Eurocode, where A_{sc} is the area of the stud and Fu is the minimum specified tensile strength of a stud shear connector (normally specified as 65 ksi in the US). This is in addition to the other equation and/or table values specified by Code. For BS 5950, Fu is not used by the program. For AISC 360-05, Rg is based on the deck dimensions and orientation, Rp is based on user specified criteria in the Design Criteria dialog , according to specification Section I3.2d(3).

For CAN/CSA-S16-01, when the rib height is between 38mm and 75mm and the deck is spanning perpendicular to the beam, the shear strength of the shear studs is determined by interpolating between the values given by the equations in Clause 17.7.2.3. Also, the value of Ap is determined using a common simplified approach that uses the average rib width and assumes that the rib edges are vertical.

For BS 5950, Qk is based on Table 5. No interpolation is performed for intermediate values. Qk is set to 0.0 kN if the stud shear connector or concrete properties fall outside of the table. Allowable values are modified as required for ribbed deck, accounting for the direction of deck relative to the beam. The program assumes that the studs are placed centrally in the rib, or in the favorable position. Concrete with a unit weight less than about 2320 kg/m^3 is considered light weight, and the Qk values get multiplied by 0.90 per Clause 5.4.6.

Considerable control over the selection of studs is given to the User. A number of parameters can be specified on the Design dialog Studs tab . You may specify the maximum percent of full composite allowed. The Code allows 100%. The minimum percent of full composite allowed may also be specified. ASD 9th Edition specifications require at least 25%. The AISC 360-05 and LRFD 3rd Edition specifications have no such requirement but the commentary indicates that less than 25% should not be used. The program treats the 25% as a Code requirement for those Codes. The other Codes have similar minimum stud requirements; the program will use the more stringent of the Code requirement and the user-specified value.

If you specify a minimum percent of full composite greater than that required by code, but an adequate number of studs to satisfy that user-specified minimum will not physically fit on the beam, the program will select as many studs as will fit.

On the Design dialog Studs tab there are two options for when the beam fails the minimum composite requirements: Use Bare Beam section properties and Use Composite section properties. If the code-specified minimum percent composite is not met, either because you specified too few studs or the required studs will not physically fit on the beam, and the Use Bare Beam section properties option has been selected, the program will design the beam as a non-composite beam and a warning will be given. The number of studs will be shown as 0. If the Use Composite section properties option has been selected, the program will analyze the beam as a composite beam even though the minimum percent composite requirement was not met. This option should therefore only be used carefully. Note that the option is relevant

only with user-specified sizes; the program will not optimize a beam size that does not meet the minimum percent composite requirements.

The program allows three rows of studs unless limited by the flange width or stud diameter/flange thickness ratio. You may also specify a maximum number of rows. If an adequate number of studs cannot fit within the number of rows specified, the program will select a larger member. You may specify the beam flange width required in order to fit double and triple rows of studs. If multiple rows are required on a beam with inadequate flange width, the program will select a larger member. Note that by using a staggered stud configuration, a smaller Minimum Flange Width may be specified. However, caution should be taken to avoid specifying a Minimum Flange Width narrower than can physically accommodate the multiple rows of studs.

When determining the occurrence of multiple rows of studs the program considers the deck orientation, flute spacing, web thickness, flange width and maximum number of rows allowed. When multiple rows of studs are required, the allowable shear value for those studs is reduced per the applicable Code requirements.

As indicated, the orientation of the deck that crosses the beam will impact the stud spacing. Normally the program assumes studs can only be placed at locations where the deck is physically supported on the beam (i.e. at the ribs). When the angle between the deck and the beam is small, there are very few ribs crossing the beam in which to put studs. As a result, there are insufficient studs to satisfy the minimum required percent composite action, and the program is unable to design the beam compositely.

In these situations the engineer will typically specify that the deck is split along the beam to allow studs to be added at a more desirable spacing. This split in the deck can either be created by compressing the deck that runs over the top of the beam, or by physically cutting or starting the metal deck on the beam. You can specify the appropriate construction detail to the beam using the Ignore Rib Spacing command found on the Composite dialog Ignore Rib Spacing tab . When the option has been selected, the stud spacing is not limited to the rib spacing; rather, the minimum allowable stud spacing is used instead. The program will however consider these construction conditions differently when calculating the stud capacities on the beam:

If the option for Altered Ribs is selected, the Stud Capacity will not be modified from what is currently calculated; the reduction for rib configuration will still be applied.
If the option for Split Deck is selected, the Stud Capacity may be modified: the normal reduction for the steel deck profile will not be applied if the beam width is at least 8” for AISC code design or at least 140mm for BS 5950 design. 8” was chosen for AISC because in AISC 360-05 User Note in Section I3.2d(3) it indicates that for split deck there is no reduction due to the deck configuration if less than one-half of the flange is covered by deck; since the required bearing length for deck is 2”, this requires an 8” flange: (2”)(2 sides)(2) = 8”. The normal reduction for the steel deck profile will always be applied to CAN/CSA S16-01 and to Eurocode; the stud capacity is not affected by the Split Deck designation.

The Beam Design report indicates those beams to which the assignment has been made.

There are certain maximum stud spacing requirements based on the orientation of the deck and the Code selected. The program selects studs conforming to those requirements. You may

specify a more stringent requirement by specifying that the maximum spacing be limited to a certain value.

All of these criteria are considered within the optimization loop, and only members that conform to all criteria simultaneously are selected. Care should be taken, therefore, not to specify conflicting criteria. If conflicting criteria are set, the program will select the member whose non-composite section is adequate to carry the loads. One example of a possible conflict is to set the value for Minimum Percent of Full Composite Allowed to a high value, while setting Maximum Rows of Studs Allowed to a low value. It may be impossible to achieve the percent of composite required without exceeding the number of rows specified. Another conflict may occur if the Maximum Percent of Full Composite Allowed is set low and the Maximum Stud Spacing is set to a small value. For smaller beams, the studs required to satisfy the Maximum Spacing may result in percent of full composite exceeding that specified.

If the number of studs that can be placed on a member is controlled by a Code- or User-specified restriction, “Max” is indicated rather than “Full”. You can, however, override any restrictions by specifying an “Actual” number of studs that exceeds the number shown for “max” in View/Update. The composite properties will be based on the actual number of studs, not to exceed full composite.

8.3.5 Stresses - ASD

Allowable stresses in large, heavily loaded composite beams.

For large, heavily loaded beams with a very small effective flange width, the optimum size may be a beam whose bare section is adequate to carry the load without composite action. In this case the program will select that size, but will call for minimum studs since you specified that the beam be designed compositely. With such a configuration for ASD it may be possible to have overstressed concrete. Since the bare beam is adequate to carry the loads this is not a problem from a capacity standpoint, but it should be noted that in calculating the deflections the program uses the composite section properties. The program will warn you that the concrete is overstressed. You can then choose to ignore the warning or else redesign the beam as a non-composite beam. Again it should be emphasized that this situation only occurs for heavily loaded beams with a very small effective flange width whose bare section properties alone are adequate for stresses.

8.3.6 Capacities - LRFD

Calculation of composite beam capacity for AISC LRFD.

For LRFD, the nominal moment capacity of the composite section is calculated to within 0.5% (due in part to the fact that round-off in the steel tables may introduce discrepancies of that magnitude), and the nominal moment capacity is deemed adequate if it exceeds or is within 0.5% of the required moment capacity.

If the beam web is not compact, the non-composite section properties, rather than the composite section properties, with the corresponding moment capacity will be used.

8.3.7 Capacities - CAN/CSA-S16-01

Calculation of composite beam capacity for Canadian code.

The nominal moment capacity of the composite section is calculated to within 0.5% (due in part to the fact that round-off in the steel tables may introduce discrepancies of that magnitude), and the nominal moment capacity is deemed adequate if it exceeds or is within 0.5% of the required moment capacity.

The program does not check longitudinal shear as described in Clause 17.9.9.

8.3.8 Capacities - BS 5950

Calculation of composite beam capacity for British code.

The nominal moment capacity of the composite section is calculated to within 0.5% (due in part to the fact that round-off in the steel tables may introduce discrepancies of that magnitude), and the nominal moment capacity is deemed adequate if it exceeds or is within 0.5% of the required moment capacity.

For high shear loads, the moment capacity is reduced as required by Clause 5.3.4.

If the plastic moment capacity of the composite section exceeds 2.5 times the plastic moment capacity of the steel beam alone, additional checks are performed as required by Clause 5.4.5.4.

Only beams with Class 1 or Class 2 flanges, based on the classification allowed by Clause 4.5.2, are selected by the program as composite beams. Only beams with Class 1 or Class 2 webs are selected by the program as composite beam. Otherwise, the beams are designed as non-composite.

8.3.9 Capacities - Eurocode

Calculation of composite beam capacity for EC4.

For Eurocode, the nominal moment capacity of the composite section is calculated to within 0.5% (due in part to the fact that round-off in the steel table may introduce discrepancies of that magnitude), and the nominal moment capacity is deemed adequate if it exceeds or is within 0.5% of the required moment capacity.

If the beam web and flanges are not in Class 1 or Class 2, the non-composite section properties, rather than the composite section properties, with the corresponding moment capacity will be used.

The section capacity is not checked for longitudinal shear or longitudinal splitting of the slab as described in Clause 6.6.6 of Eurocode 4.

For the unusual case where the plastic resistance moment exceeds 2.5 times the plastic resistance moment of the steel member alone, Clause 6.6.1.3(4) of Eurocode 4 requires that the adequacy of the studs be checked at intermediate points approximately midway between adjacent "critical cross-sections", which in the program's case is the location of point loads and point of maximum moments; the program does not perform this additional check.

When the vertical shear, V_{Ed}, exceeds half the shear resistance, V_{Rd}, Clause 6.2.2.4(1) of Eurocode 4 requires that an allowance be made for its effect on the resistance moment. Clause 6.2.2.4(2) gives a method for considering a reduced design steel strength (1-ρ)fyd in the shear area, where ρ is given by Eq. (6.5); the program conservatively ignores the contribution of the web to the resistance moment in that case (in other words, the program conservatively uses a value of ρ equal to 1.0 which would be the case if V_{Ed} equaled V_{Rd}).

8.4 Non Composite Beam Design

Design of non-composite members and composite members under certain conditions.

Beams you specify as Composite will automatically be designed as Non-composite in the following cases:

- There is no positive moment;
- The maximum negative moment (as for a cantilever) is more than twice as large as the maximum positive moment on the beam.

In the calculation of the lateral torsional buckling capacity for a section of beam with an unbraced compression flange, the location of load application on the beam can have an impact on the beam's capacity. For AISC 360-05, AISC ASD, AISC LRFD, CAN/CSA-S16-01, and BS 5950, the load is assumed to be applied at the shear center of the section.

For the Eurocode, you can specify whether the load is applied at the top flange or at the shear center by choosing the appropriate setting in the Design Criteria dialog Eurocode Factors tab .

8.4.1 CAN/CSA-S16-01

Calculation of capacity of non-composite sections per Canadian code.

For unsymmetrical flange sections the following equation per SSRC has been implemented to calculate the lateral torsional buckling capacity:

$$M_{cr} = \frac{\omega 2 * E}{Ky * L}\left\{\sqrt{E * Iy * G * J}\,(B_1 + \sqrt{1 + B_2 + B_1^2}\right\}$$

Where:

$$B_1 = \frac{\pi * \beta_x}{2 * Ky * L}\sqrt{\frac{E * Iy}{G * J}}$$

$$B_2 = \frac{\pi^2 * E * C_w}{(Ky * L)^2 * G * J}$$

$$\beta_x = 0.9d'(2 * \frac{Iyc}{Iy} - 1)\left[1 - \left(\frac{Iy}{Ix}\right)^2\right]$$

d' = distance between center of the top and bottom flange,

Iyc = The moment of inertia of the compression axis about the section minor axis.

The bending capacity of class 3 is considered to be the compression flange section modulus multiplied by the design yield strength.

Channels are designed using the symmetrical provisions of the design specification with the assumption that loading is through the shear center.

8.4.2 BS 5950:1990

Calculation of capacity of non-composite sections per the BS 5950:1990 standard.

The program calculates the buckling capacity based on the Draft Amendments to BS5950 Structural Use of Steelwork in Building. Part 1:1990, Dated April 20th 1998. In these proposed amendments the calculation of an equivalent uniform moment factor (m_{LT}) has superceded the calculation of the slenderness factor n and the old equivalent uniform moment factor (m). The calculated value of m_{LT} is provided on all detail output.

The bending capacity of class 3 is considered to be the compression flange section modulus multiplied by the design yield strength.

8.4.3 BS 5950:2000

Calculation of capacity of non-composite sections per the BS 5950:2000 standard.

Provisions of the BS 5950 “Structural use of steelwork in building: Part 1, Code of practice for design: rolled and welded sections” (2000), have been implemented. In each steel design module the engineer is provided the option of either designing to BS59501:1990 or to BS5950-1:2000. The implications of the new code on both user interface and design methodology are described in this section.

BS 5950 Parameters

The implementation of the BS5950-1:2000 requires that the engineer provide additional design criteria. These criteria refer to the type of hollow structural sections to be used on the project, and the height of the restraint of fully braced beam flanges. These criteria are discussed in detail below, but both pieces of information are provided to the program in the Design Criteria dialog Steel Section Options tab. The two values stipulated in this dialog have no impact on the design results performed according to BS 5950-1:1990.

Hollow Structural Sections

BS5950-1:2000 stipulates different design requirements for cold-formed and hot-finished hollow structural sections (HSS). The HSS type affects the classification of the cross section (see table 12 in BS5950-1:2000), and the web shear interaction as described in

H.3 of BS5950-1:2000. The engineer can stipulate which type of HSS they are using in the Design Criteria dialog Steel Section Options tab.

Distance to Axis of Restraint

BS5950-1:2000 has changed the method in which the lateral torsional bending capacity of beams is calculated. In certain circumstances, where the tension flange of a beam is fully braced and the compression flange unbraced, the height of the restraint to the tension flange affects the bending capacity of the member (See BS5950-1:2000 4.3.5.3c, Annex G.1. and G.2.). This will typically affect the design of cantilever or continuous members in the zone where the unbraced lower flange is in compression. The engineer can stipulate the distance from the top-of –flange (tension), to the center of the restraint of that flange, in the Design Criteria dialog Steel Section Options tab.

Tables

Two steel tables provided with the program contain the cold-form hollow structural sections. These tables are `RAMUK_CF.tab` and `RAMUK_CF.bms`. The `RAMUK_CF.tab` file includes the section properties of the typical UB and UC sections, and also the properties of the common cold-formed hollow structural sections (HSS). These HSS comply with the requirements of BS EN 10-219. The filename suffix _CF indicates that the HSS designations and properties in these tables are for Cold Formed sections. These tables DO NOT contain data related to hot-finished hollow sections. The `RAMUK_CF.bms` table contains the same data as the existing RAMUK. bms table, except cold-form hollow sections are listed instead of the hot finished sections.

Bending Capacity

- Loads are not considered 'destabilizing' per 4.3.4. However, the engineer has the option of supplying the appropriate Le factor per table 13 or 14 in the Design Defaults tab of the Criteria – Design command.
- For lateral torsional buckling per 4.3.6.7 the u and x term are calculated per B2.3, not 4.3.6.8.
- The monosymmetry index Ψ is calculated per 4.3.6.7. In the case of highly unsymmetric sections, with values of n outside the range of 0.1 to 0.9, the engineer is responsible for calculating the appropriate buckling capacity.
- For channels, loads are assumed to be pass through the shear center per 4.3.6.7b.
- G.2. is implemented for I-sections where the tension flange is fully braced and the program is calculating the lateral torsional buckling capacity of the unbraced compression flange. When G.2. is implemented for a beam, the program sets mLT = 1.0 and calculates nt based on the shape of the moment diagram. In the calculation of Mb in section G.2. there is a reference to the distance between the axis of restraint and the axis of the beam. In the program this distance is determined from the distance between top-of-steel and axis-of-restraint, as specified by the engineer. This calculation will only apply where the engineer indicates that the top-flange is fully braced. Where the bottom flange is fully braced the dimension is assumed to be half the depth of the beam.

Section Capacity

- For class 3 sections the program uses the elastic section modulus in all cases, it does not calculate an effective plastic modulus as allowed by 4.2.5.1.
- Per 4.2.5 Mc is limited to 1.2pyZ.

Cross Section Classification

Cross sections are classified as plastic, compact or semi-compact. No consideration is given to slender (Class 4) sections. Sections of class 4 will be flagged and reported as an error.

8.5 Design Yield Strength

Methods used to determine the design yield strength using various standards.

8.5.1 AISC 360-05 and AISC ASD and LRFD

The design yield strength, Fy, is the value specified by the user. No reduction is made for thick sections.

8.5.2 CAN/CSA-S16-01

The design yield strength is associated with the members material grade as defined in Table 6-3 of the CISC handbook of Steel Construction, Seventh Edition. To assign the grade for a member the engineer selects the appropriate material type using the Design Criteria dialog Steel Material tab. The engineer assigns a nominal yield strength (Fy) to the beam section. Based on the combination of the nominal yield strength and the material type a grade is selected. For example a nominal Fy of 350N/mm^2 and a material type W results in a section of grade 350W. Note that a nominal yield strength slightly less than 350N/mm2 will result in a section of grade 300W. If no appropriate grade is available (based on the user-entered values) then the design yield strength will effectively be set to 0.0 and “NoGrade” will be assigned as the grade for the section.

8.5.3 BS 5950

The design yield strength is the yield strength according to the material grade as defined in Table 6 of BS5950:Part1:1990 and in Table 9 of BS5950:Part1:2000. To assign a grade to a section the engineer assigns a nominal yield strength (py) to the beam section. Based on the magnitude of the nominal yield strength the section is assigned a grade from the table. If the nominal yield strength is within a range of yield strengths indicated in the table then the associated grade is assigned to the section and the rules relating material thickness to design yield strength are followed. If the nominal yield strength is not within a range of yield strengths indicated in the table then the design yield strength is assigned the nominal yield strength value, and no reduction is made for material thickness. The design yield strength will never be larger than the engineer provided nominal yield strength. For composite construction, py is limited to 355 N/mm^2 as required by Clause 3.1.

8.5.4 Eurocode

For steel with a nominal fy less than or equal to 460 N/mm²and greater than or equal to 275 N/mm² the design yield strength is adjusted to account for material thickness according to Table 3.1, BS EN 1993-1-1:2005, EN10025-3 rules. Both nominal and design Fy appear on all design output. Steel with a nominal fy larger than 460N/mm² or less than 275 N/mm² is assigned no design yield.

For steel with a nominal Fy outside of the ranges specified no steel material will be found and the section will be assigned a small yield strength and fail in design. A large interaction value on a design is indicative of assigned yield strength outside the ranges indicated above.

Yield strength depends on the thickness of the elements (flange, web, etc.) of the cross section being designed. Refer to table 3.1 of BS EN 1993-1-1:2005 for details on the material and yield strengths for different thickness elements.

8.6 Material Properties

The values of Modulus of Elasticity, E, and Shear Modulus of Elasticity, G, for steel are used by the program.

8.6.1 AISC 360-05 and AISC ASD and LRFD

Modulus of Elasticity E = 29,000 ksi

Shear Modulus of Elasticity G = 11,200 ksi

8.6.2 CAN/CSA-S16-01

Modulus of Elasticity E = 200,000 Mpa

Shear Modulus of Elasticity G = 76,923 Mpa

8.6.3 BS 5950

Modulus of Elasticity E = 205 kN/mm²

Shear Modulus of Elasticity G = 78.85 kN/mm²

8.6.4 Eurocode

Modulus of Elasticity E = 210,000 N/mm²

Shear Modulus of Elasticity G = 81,000 N/mm²

8.7 Cross Section Classification

Methods used for various standards.

Under CAN/CSA-S16-01, BS 5950, and Eurocode, sections are classified as Class 1 (Plastic), Class 2 (Compact), Class 3 (Semi-compact) or Class 4 (Slender) based on member dimensions and applied loads. No consideration is given to slender (Class 4) sections. Sections of class 4

will be flagged and reported as an error. No axial force or minor axis bending is considered in the program. The following rules apply to the classification of all members:

- Each element (flange, web) of a section is evaluated independently. The highest element class value will be assigned to the member as a whole.
- Any element (flange or web) required to resist axial compression load will be evaluated to determine into which class the element falls.
- Any element (flange or web) required to resist axial tension load only will be assumed to be class 1.
- A flange element, which carries tension due to bending moment, will be class 1.

8.7.1 Cross Section Classification Error Messages

These error messages may appear during the design process.

CAN/CSA-S16-01

"Class 4": If a section contains a slender element it will be indicated as a class 4 section and no additional design checks will be performed.

"Slender Web": If a section subject to shear has a web whose depth to thickness ratio exceeds the limit of 502sqrt(kv/Fy) then no further design checks will be performed.

BS 5950

"Class 4": If a section contains a slender element it will be indicated as a class 4 section and no additional design checks will be performed.

Eurocode

"Class 4": If a section contains a slender element it will be indicated as a class 4 section and no additional design checks will be performed.

8.8 Cantilevers

In addition to being designed for the moments and deflections in the span using the composite section for composite beams, beams with cantilevers are designed for the moments and deflections in the cantilever based on the bare beam section.

In the post-composite deflection calculations, Ieff is used along the whole span and Ix is used along the whole cantilever.

If a significant portion of the span is in negative moment, the use of Ieff for the entire span may be unconservative.

The program assumes that the maximum cantilever deflection occurs at the cantilever end, and that the maximum cantilever moment occurs at the support.

Cantilevers are not checked for the construction Dead Load only case.

8.9 Unbraced Length

Unless specified otherwise, the program determines unbraced lengths and sizes the members accordingly.

You may specify a number of parameters related to unbraced length considerations. These criteria are found in the Design Criteria dialog Design Defaults tab. You may suppress entirely the checking of unbraced length by de-selecting the Check Unbraced Length option. In this case, all beams are designed as if the compression flange is continuously braced for the full length of the beam. This speeds up the design process but may result in unconservative results, and is not generally recommended.

You may indicate whether or not the deck braces the top flange for non-composite and precomposite design. For non-composite beams this is specified in the Span Definition dialog; for precomposite beams this is done on the Design Criteria dialog Design Defaults tab. The effect of deck oriented parallel to the beam may be specified independently of that of deck oriented perpendicular to the beam. See Deck Orientation for a discussion of perpendicular versus parallel deck. For composite beams the deck is always assumed to brace the top (compression) flange in the positive moment region, except in the precomposite state the flange bracing is based on the parameters specified. The program assumes that the deck does not brace the compression flange of cantilevers and beams in the negative moment region.

For cantilevers, the program assumes that the ends are fully braced against twist.

One of the criteria available is an option to Consider Point of Inflection. Selecting this option does not mean that the point of inflection will necessarily be considered a brace point; rather, it affects the way the program looks at brace points of the flanges on either side of the point of inflection when determining the unbraced length. This is further explained below.

In the program, one flange brace point list is created for the top flange and another is created for the bottom flange. These brace points are determined in the following way:

- Beams are assumed to be braced at supports on both the top and the bottom flange.
- Cantilever ends are assumed to be braced on both the top and the bottom flange.
- User-assigned brace points, specified in the Bracing dialog , brace the specified flange.
- For composite beams in the composite state, the deck is assumed to brace the top flange in the positive moment region.
- For the precomposite state of composite beams the deck is assumed to brace the top flange according to the criteria specified for Unbraced Length in Design Criteria dialog Design Defaults tab. You may indicate whether or not the deck braces the top flange when the deck is oriented parallel to the beam and when it is oriented perpendicular (or at an angle) to the beam.
- For non-composite beams the top flange is braced or not according to the option specified in the Span Definition dialog.

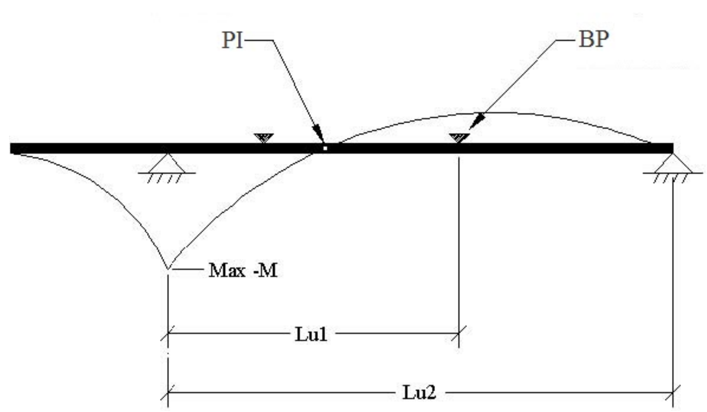
When determining the moment capacity associated with a moment at a given point, if the moment causes compression in the top flange and the top flange is braced by the deck, the unbraced length is set to 0.0.

Note that the calculation of the unbraced length is affected by whether or not the Consider Point of Inflection option is selected. If the option is not selected, the unbraced segment length is the distance between physical brace points along the flange under consideration. For example, in the figure below, L_{u2} would be the unbraced length for the Moment at the left support. This would be used even though the bottom flange is only in compression between the left support and the point of inflection; it is in tension from the point of inflection to the right support. L_{u2} is the distance between bottom flange physical bracing, which in this example is the entire beam span. This is consistent with the recent work by Joseph A. Yura of the University of Texas, Austin.

If the Consider Point of Inflection option is selected, the unbraced length is the distance between points where the compression flange (whichever flange is in compression at any particular point) is braced, not the distance along a given flange where that flange is braced. For example, in the figure below, L_{u1} would be the unbraced length for the Moment at the left support because at the left support the bottom flange is in compression but at the point of inflection the top flange becomes the compression flange, and that flange is braced at the second top flange brace point. L_{u1} is the distance between compression flange bracing. This is consistent with what has been long-standing practice; see, for example, the publication "Cantilever Roof Framing Using Rolled Beams" published by AISC.

Points of inflection are not of themselves considered brace points. However, if the top flange is specified as continuously braced, the point at which the continuous bracing of the compression flange begins or ends coincides with the point of inflection. In the figure below, if the top flange is continuously braced and the Consider Point of Inflection option is not selected, the unbraced length would still be L_{u2} as shown. However, if the top flange is continuously braced and the Consider Point of Inflection option is selected, the unbraced length would be the distance between the left support and the point of inflection (not L_{u1}). Thus, although the point of inflection appears to be acting as a brace point in that case, it is actually the continuous bracing that is acting as the brace 'point'.

Figure 8-2: PI is the Point of Inflection and BP is the Top Flange Brace Points



The sign convention used in Figure 4-2 is such that the moment curve is drawn on the same side as the compression flange.

Based on these criteria and the geometry of the model, the program automatically determines the braced condition for each member.

Unbraced length is taken as the distance between brace points. At supporting columns, it is taken to column centerline, not column face.

The program checks each unbraced segment to determine the controlling condition of moment and unbraced length, and selects the beam size accordingly.

8.9.1 ASD and LRFD

When calculating the allowable stress (ASD) or moment capacity (LRFD) of an unbraced segment, the program calculates Cb based on the end moments of the segment. Although not required by Code, you may conservatively specify that Cb be set equal to 1.0 for all simple span non-composite beams. You may also specify that Cb be set equal to

1.0 for all cantilevers, as recommended by the Codes and other sources. Otherwise, the program will calculate and use the values of Cb as allowed by the appropriate Code.

The output shows the values of stress/capacity, unbraced length, and Cb at the points of maximum and minimum moments as well as the controlling condition. Note that the controlling condition may not correspond to any of the maximum or minimum moment conditions; this indicates that the controlling condition occurs in a segment with a lesser moment but greater unbraced length.

8.9.2 CAN/CSA-S16-01

The effective length of a beam can be controlled by setting the criteria from the Design Criteria dialog Design Defaults tab. The specifications of CAN/CSA-S16-01 have been implemented with the following modifications according to the Structural Stability Research Council (SSRC), "Guide to stability Design Criteria for Metal Structures", Galambos, 1998.

For cantilever beams the effective length is taken as 1.5 times the unbraced length. This assumes the cantilever tip is restrained against torsion. Omega 2 (w2) is taken as 1.0 for cantilevers.

8.9.3 BS 5950

The effective length of a beam can be controlled by setting the criteria from the Design Criteria dialog Design Defaults tab. The effective length (Le) of the unbraced segment depends on the end conditions of the segment. The following assumptions are made by the program unless overridden in the Design Criteria dialog Design Defaults tab. Loads are assumed to be normal loads (applied at the shear center). For a segment continuous through brace points, Le is equal to the unbraced length. Where a beam is continuous through a column or supporting girder an effective length factor of 0.7 is assigned to that end of the segment. This is indicative of the column providing the beam a measure of restraint for bending about the minor axis. Where a beam is pinned at a support, or where a cantilever tip occurs, the effective length factor is taken as the value provided by the engineer in the Design Criteria dialog Design Defaults tab. The effective length factor for an entire segment is taken as the average of the factors at the segment ends.

8.9.4 Eurocode

Within each unbraced segment the points of maximum moment and shear and the segment end points are all checked against the segment capacity.

When calculating the member capacity for an unbraced segment the lateral torsional buckling must be considered. In these cases it is necessary to calculate the elastic critical moment (Mcr).

While BS EN1993-1-1:2005 does not provide exact information on how to compute Mcr RAM SBeam calculates the elastic critical moment using procedures, described in these articles:

1. SN003a-EN-EU "NCI: Elastic critical moment for lateral torsional buckling"
2. M.A Serna, A.Lopez, I. Puente, D.J. Yong "Equivalent uniform moment factors for lateral-torsional buckling of steel members" (2006) Journal of Constructional Steel Research, 62.
3. Rubrique du Praticien, "Abaques De Deversement Pour Profiles Lamines", Construction Metallique no 1 - Mars 1981.

RAM Frame assumes that the factors k and kw are equal to 1.0. The following procedures are implemented to calculate the C factors, depending on the beam major axis loading:

Members with end moments only – according to French Annex:

$C1 = 1/(\sqrt{0.325 + 0.432\ \psi + 0.252\ \psi^2})$

$C2 = 0.0$

$C3 = 0.5(1.0 + \psi)\ C1$

If end moments negative, middle positive, shape of moment is symmetric and there is a straight line between center and ends of segment use case 4 from SN030a-EN-EU, table 4.2:

$C1 = 1.68$

$C2 = 1.64$

$C3 = 2.64$

If end moments negative, middle positive, shape of moment is symmetric and there is no straight line between center and ends of segment use case 2 from SN030a-EN-EU, table 4.2:

$C1 = 2.57$

$C2 = 1.55$

$C3 = 0.75$

If end moments are zero and shape of moment is symmetric and there is straight line between center and ends of segment use values from case 3 SN030a-EN-EU, table 4.2:

$C1 = 1.35$

$C2 = 0.63$

C3 = 1.73

If end moments are zero and shape of moment is symmetric and there is no straight line between center and ends of segment use French Annex formulas based on the procedure detailed in the French Journal, Rubrique du Praticien, “Abaques De Deversement Pour Profiles Lamines”, Construction Metallique no 1 - Mars 1981:

C1 = C_1^o|Mmax/M|

C2 = $4/\pi^2$ |μ| C_1^o

C3 = 0.525 if ends pinned, 0.753 if ends fixed, 0.64 for one end pinned, other fixed.

where:

$$C_1^o = \sqrt{1+\gamma+\left(\frac{1}{3}+\frac{1}{2\pi^2}\right)(\gamma^2-8\mu)-2\gamma\mu\left(1-\frac{3}{\pi^2}\right)+8\mu^2\left(\frac{2}{5}-\frac{2}{\pi^2}+\frac{3}{\pi^4}\right)}$$

$\gamma = 4\mu + \beta - 1$

$\mu = fL^2/(8M)$

f = Uniform Load

M = Maximum End Moment

L = Member Length

For all other cases use formula (13) from M.A. Serna article "Equivalent uniform moment factors for lateral - torsional buckling of steel members":

$$C1 = \frac{\sqrt{\sqrt{k}A_1+\left[\frac{\left(1-\sqrt{k_1}\right)}{2}A_2\right]^2}+\frac{\left(1-\sqrt{k}\right)}{2}A_2}{A_1}$$

C2 = 0.0

C3 = 0.0

where:

$$A_1 = \frac{M_{max}^2+9kM_2^2+16M_3^2+9kM_4^2}{(1+9k+16+9k)M_{max}^2}$$

$$A_2 = \left|\frac{M_{max}+4M_1+8M_2+12M_3+8M_4+4M_5}{37M_{max}}\right|$$

Coefficient k is related to the lateral bending and warping prevention at end supports. It is equal to 1 if lateral bending and warping are free and equal to 0.5 if lateral bending and warping are prevented. Moments M_1 and M_5 are begin and end moments respectively, moment M_3 is the moment at the middle of the span, moment M_2 is moment on L/4 position and moment M_4 is the moment on 3L/4 position. Moments M_1 through M_5 must have its corresponding signs.

> **Note:** Values of C for cantilevers are calculated as for all other members as RAM SBeam assumes the ends of a cantilever to be laterally braced.

The output shows the values of: class, the design shear and moments at the indicated beam location, the segment unbraced length (Lb), the type of moment that controls the member capacity (Mb = buckling, Mc = plastic capacity, Mv = is shear reduced capacity) and the member capacity. Note that the controlling condition may not correspond to any of the maximum or minimum moment conditions. This indicates that the controlling condition occurs in a segment with a lesser moment but greater unbraced length.

8.10 Deflection

When selecting beam sizes, the program investigates the acceptability of the deflections based on the specified limiting deflection values and span-to-deflection ratios, L/d.

You can specify the limits on the construction dead load deflection, the total dead load deflection, the live load deflection, and the total deflection.

The program first calculates the point at which the maximum total deflection occurs, then compares the deflection limitations against the other deflection values that occur at that point. For example, if the maximum total deflection occurs at, say 15', the values of the deflections for the construction dead load, total dead load, and live load at that point are determined and compared against the limitations, even though for unusual loading patterns their maximums may not necessarily occur at that same point.

All deflection calculations are based on unfactored loads.

The value calculated, shown, and used for the total deflection is the Net Total Deflection. It is the total deflection minus the specified camber, if any.

For cantilevers, the L/d ratio is calculated using twice the cantilever length.

8.10.1 AISC 360-05, AISC LRFD 3rd and AISC ASD 9th

Equation (C-I3-3) of the Commentary to Section I3.1 of the AISC Steel Construction Manual, 13th Edition, gives the value of Iequiv. Earlier in that section it indicates that Ieff should be taken as 0.75Iequiv. Historically this has not been common standard practice so it is not automatically performed by the program, but is presented as an option in the Design Criteria dialog Studs tab when any of the AISC codes are selected.

8.10.2 CAN/CSA-S16-01

For composite design the deflections under the post-composite loads are based on an effective moment of inertia as given in Clause 17.3.1. To account for creep the deflections caused by dead loads and long term live loads are increased by 15%.

Shrinkage deflection is also calculated and included in the deflection results. Criteria that affect these values can be specified using the Deflection tab of the Deflection Criteria dialog.

8.10.3 BS 5950

For composite design the deflections under the post-composite loads are increased to account for the affects of partial shear connection per Clause 6.1.4.

8.10.4 Eurocode

To account for the effects of creep and shrinkage on the composite section, a modified modular ratio, n, is used per EN 1994-1-1:2004 Clause 5.4.2.2(11).
When the conditions of Clause 7.3.1(4) are met the effects of incomplete interaction (i.e., partial composite) is ignored for the calculation of the deflections under the post-composite loads. When the conditions of that clause are not satisfied, no methodology for calculation of deflections is given. The methodology given in Clause 5.2.2(6) of ENV 1994-1-1:1992, which is identical to that given in BS 5950:Part 3:Section 3.1:1990 Clause 6.1.4, is used.

8.11 Camber

The required beam camber is calculated using the criteria specified in the Camber Criteria dialog.

Camber is calculated based on the deflection resulting from the beam design. If you need to limit or eliminate camber by limiting the deflection, more stringent deflection criteria can be specified. The camber is based on the Total Dead Load deflection for non-composite and shored composite construction and on the Construction Dead Load deflection for unshored composite beam design.

The program calculates the dead- or construction dead load deflection, takes a percentage of that you specify, and rounds down to the nearest Camber Increment. That result is compared against the Minimum Camber value also specified; if that value is less than the Minimum Camber, no camber is indicated on the output. It is also compared against the Maximum Camber value specified; if that value is greater than the Maximum Camber it is limited to the Maximum Camber value. This result is the value of camber shown on the output.

Camber can be suppressed by selecting the **Do Not Camber** option. It can also be suppressed on very large or very small beams or on beams whose span is very short.

There are separate criteria that can be specified for composite vs non-composite beams.

The Camber criteria may affect the beam design if the design is controlled by Net Total Deflection.

For CAN/CSA-S16-01, camber is based on the elastic deflection; the camber value has not been increased by 1.15 to account for creep, nor has it been increased to account for the additional deflection due to shrinkage. If you wish to have camber increased to account for these, the percent of Dead Load to be used for camber can be specified as 115% or whatever value desired, using the Camber Criteria dialog.

8.12 Shear

When checking web shear stresses and capacities, the full cross-sectional area of the web is considered; block shear and other connection related shears and capacities are not checked.

The shear diagrams are the shears produced by the loading that produced the maximum moments. For simple span beams with positive loads, these shears will represent the maximum shears, but for cantilevered beams or beams with negative loads, the diagrams may not represent the maximum shears if the skip load pattern which produced the maximum moments differs from the skip load pattern that would produce the maximum shears. This applies to the diagrams only; the shear design is based on the actual maximum shears as explained below.

On the report the value listed as Maximum Shear is based on the assumption that the maximum occurs at the supports. Web shear stresses are checked for the maximum shears that occur at the supports only.

For Eurocode shear is typically considered along with the moment at a section. The Eurocode report shows the maximum shear (VzEd) on the span and the plastic web resistance (VplRd).

8.13 Optimization

The beam design optimization is controlled by the order of the beam sizes in the design tables.

It is assumed that the sizes are ordered in the optimum (generally, least weight) order. Unless the selected size is overridden, the program will then select the optimum member. In the case of the `RAMAISC.BMS` table provided with the program, if the design is not controlled by unbraced length or a depth restriction, members selected will correspond to the beams in bold type face in Allowable Stress Design Selection Table - S_x for ASD or in Load Factor Design Selection Table - Z_x for LRFD with the following exceptions:

- W18x35 and W16x31 will be selected in lieu of W14x34 and W14x30, respectively, unless limited by user-specified depth restrictions.
- M shapes are not included in the optimization table.
- W10x12 and W8x10 are included in the optimization table.

When beams of equal weight but different depth are both adequate, the deeper beam will be selected unless limited by user-specified depth restrictions.

When no beams are adequate for the loads and conditions specified, the output will indicate No Design. This indicates to the user that special consideration is required for this member.

8.14 Size and Depth Limitation

A maximum and minimum beam depths can be specified using the Size Restriction options in the Span Definition dialog.

When a maximum depth restriction is specified, the program first determines the optimum beam size. If the optimum size exceeds the specified depth restriction, the program selects the lightest section smaller than that depth which is adequate. If no beams smaller than the given depth are adequate, the depth restriction criteria is ignored, a warning message is given, and the optimum size is selected.

Under some circumstances it is desirable to select beam sizes that are deeper or wider than would otherwise be required for capacity or deflection. Minimum beam depth and flange width can be specified using the Size Restriction options in the Span Definition dialog. During optimization the program will reject any sizes whose depth or width are smaller than the values specified.

The minimum beam depth can also be controlled by specifying a maximum allowable span-to-depth ratio using the Span/Depth Limit option in the Span Definition dialog. It is not a Code requirement, but a common rule-of-thumb. If a criteria is specified, the program will reject any size whose depth is too small to satisfy the criteria.

The depth restriction values specified are absolute depths, not nominal depths.

8.15 User Defined Rolled and Built up Shapes

The program can design and optimize members based on a user-supplied table of built-up shapes.

In certain cases, some economy may be realized by specifying built-up shapes rather than standard rolled sections. The traditional design of such members, however, is made more difficult due to the necessity of checking for compactness and slenderness, with the corresponding allowable stresses and moment capacities. The program checks the web and flanges for compactness and slenderness criteria of welded shapes, and calculates the appropriate allowable stresses for ASD and capacities for LRFD, CAN/CSA-S16-01, BS5950, and Eurocode. Either composite or non-composite construction may be specified.

Designs may also be performed using User-defined rolled shapes. This enables designs using shapes common in Europe, Japan, etc. The tables may be in either English or SI units. Allowable stresses are dependent on whether the members are rolled shapes or built-up shapes as specified in the table.

See Appendix A for more information on creating and modifying tables.

In LRFD, Mp is limited to the smaller of ZxFy and 1.5SxFy. For shapes whose top and bottom flanges differ, the program uses the smaller of Sx calculated for the bottom flange and Sx calculated for the top flange when calculating the value for 1.5SxFy.

When calculating the allowable shear stress and shear capacity, the program assumes that there are no transverse stiffeners.

8.16 Vibration Analysis

The program can utilize the simplified approached commonly used in the United Kingdom for composite beams.

The perceptibility of vibration of a floor system is dependent upon a complex interaction of the slab, beams and girders. In order to accurately determine the perceptibility, the entire bay must be analyzed, not just a single beam. Hence, except for the simplified approach commonly used in the UK as described below, no vibration analysis is performed by the program.

8.16.1 Vibration, Frequency and BS 5950

A simplified method of designing for vibration is commonly used in the UK and has been implemented in the program for composite beams. This method is based on calculating and limiting the natural frequency of the beam. When either BS 5950:1990 or BS 5950:2000 is selected as the Steel Design Code, an additional set of Criteria items to specify the Minimum Frequency allowed are available in the Design Criteria dialog Vibration tab. A different value can be set for short span beams than for long span beams. Specifying limits of 0.0 means that there are no limits; the Simplified approach will not be used to check and control vibration.

The natural frequency, f, is calculated from:

$$f = 18/\sqrt{(\delta)}$$

where:

δ is deflection, in mm, under self-weight, dead load and 10% of the characteristic imposed load, applied to the full composite section using the short term modular ratio.

If a limit has been set for the frequency of a given beam, the program will calculate the frequency. The following simplifying procedures and assumptions will be used:

- The short term modular ratio will be used: 6 for Normal Weight , 10 for Light Weight, per Table 1.
- The full composite section, Ig, will be used.
- The Total Dead Load and 10% of the Live Load will be applied for the calculation of the deflection. For this calculation all of this load will be applied to the composite section, not part to the precomposite section and part to the composite section.
- The beam will be assumed to be simply supported, not continuous with supports or adjoining beams. You have the option of increasing the stiffness, Ig, by 10% to account for the increased dynamic stiffness.

The natural frequency will then be calculated. If the frequency is less than the minimum specified, the beam size will be rejected. This simplified vibration check is part of the beam optimization routines and will cause the beams sizes to be increased if necessary to satisfy the criteria. A warning will be given if a user-specified size does not conform to this criteria.

For beams with cantilevers, only the frequency based on the span deflection will be considered; the cantilever frequency will not be calculated.

The frequency information is listed on the Gravity Beam Design report for composite beams. This information is listed even if no minimum criteria is specified.

8.17 Web Openings

Web openings can be specified using the Layout Web Openings dialog. During design, the effects of the openings are considered, and stiffeners are designed and specified if needed.

Web openings can be used in conjunction with the AISC 360-05 ASD, AISC 360-05 LRFD, ASD 9th, LRFD 3rd, and the BS 5950 steel design codes. Web openings are ignored if any other design code is selected. The design code is selected in the Design Criteria dialog.

When AISC ASD or LRFD is selected, the design of the web openings is based on:

Steel Design Guide #2: Steel and Composite Beams with Web Openings, David Darwin, 1990, published by AISC.

When BS 5950 is selected, the design of the web openings is based on:

Design for openings in the webs of composite beams, SCI Publication 068, R.M. Lawson, 1987, published by Steel Construction Institute.

These two publications will be subsequently referred to herein as Design Guide #2 and SCI Publication 068, respectively.

Criteria related to the stiffeners can be specified in the Web Openings dialog including yield strength, dimension limitations and placement of stiffeners.

The minimums and increments of the dimensions of the stiffener plates can be specified. The program will select stiffeners, when necessary, that are sized as required but that are at least the minimum size specified. The sizes are rounded up to the multiple of the increment specified.

Stiffeners placed on only one side of the web are often acceptable and more economical. They are not always desirable, however, because they cause the beam to be asymmetrical (which can be a problem in cases of long unbraced lengths). The program will investigate the design of web openings with stiffeners on one side of the web if that option is selected, otherwise it will not.

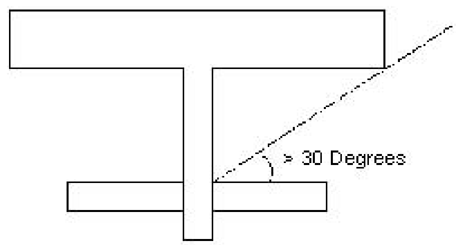
It may be more economical to use deeper, heavier beams rather than adding any stiffeners. If neither option to allow stiffeners is selected, the program will optimize to the beam size that does not require stiffeners at the openings. On the other hand, if depth of beams is a concern, lighter, shallower beams may be obtained if stiffeners are allowed.

The design of web openings is performed automatically as part of the beam design process. This is done by selecting **Process** > **Design**. During the optimization process, sizes that do not satisfy the web opening requirements will be rejected. The resulting optimized size and

shear studs will be those that satisfy all of the web opening requirements in addition to the regular beam strength and serviceability requirements.

Web openings are only permitted in I-shape steel gravity beams. If openings have been assigned to a steel beam of another shape, a Design Warning is given during design, and the opening is ignored.

Figure 8-3: Welding access provisions for stiffeners



When stiffeners are investigated or specified, the program determines if the tee is of sufficient depth to accommodate the stiffener. This includes a requirement that the clear space between the face of flange and face of stiffener be such that it gives at least a 30 degree angle between the tip of flange and the stiffener weld line (see the previous figure). This requirement is meant to ensure that there is adequate space between the flange and the stiffener to perform the welding. A design warning will be given if the tee is of insufficient depth.

During optimization, the size of stiffener plates considered by the program is limited to a thickness no greater than 1.5 times the flange thickness and a width that will not protrude wider than the beam flange. These are somewhat arbitrary, but reasonable, limitations. Larger stiffener sizes can be investigated by clicking the Analyze button in the View/Update dialog.

During optimization of composite beams, if the current configuration of beam size and studs is inadequate, the program will first try adding additional studs before trying to add stiffeners. If the beam size being investigated does not work even with additional studs, the program will try adding stiffeners. Adding studs takes precedence over adding stiffeners, as it is likely more economical to add additional studs than it is to add stiffeners.

8.17.1 Design Guide #2

Note: You should familiarize yourself with the requirements of the Design Guide. Important technical information is contained therein that is not repeated here.

Although Design Guide #2 was written prior to the publication of AISC 360-05, the program designs web openings in conformance with AISC 360-05 when that is the selected code. Some modifications were made to the implementation of the requirements in Design Guide #2 to align those requirements with those of AISC 360-05. For example:

- For AISC 360 LRFD the f factor used for composite design is 0.9 rather than 0.85.

- For AISC 360 ASD the capacities and checks are calculated as for LRFD, except the ω factor and the ASD Load Combinations are used. This also affects the fillet weld capacity on the stiffeners.

The provisions of Design Guide #2 are not valid for steel with Fy greater than 65 ksi. The program does not verify that this requirement is met; web openings should not be assigned to beams with Fy greater than 65 ksi.

Equations (3-6) through (3-10) and the analogous Equations (5-10) through (5-17) are simplified approximate equations. The program does not use those; rather, it calculates the actual plastic moment capacities of the cross section.

Stiffeners are assumed to be placed 0.5” clear from the edge of opening, rather than flush with the opening. Stiffener welds are assumed to be continuous on both sides of the stiffener plate.

Requirement 3.7(a)3 addresses buckling of the tee-shaped compression zone. Few definitive requirements are given. As specified, this check is only performed for precomposite and non-composite tees in compression; it is not performed for the composite tee. For unreinforced openings, this check is not performed on tees whose aspect ratio is less than or equal to 4.0. For reinforced openings the design guide ambiguously states that the check is only required for large openings in regions of high moment. Based on a clarification from AISC, this check is not required on any opening, reinforced or unreinforced, whose tees have an aspect ratio less than or equal to 4.0. When the aspect ratio is greater than 4.0 the check is performed, and the capacity of the tee is calculated ignoring any contribution of stiffeners. The axial load in the tee is simply computed as the ultimate moment at the opening divided by the moment arm between the elastic neutral axes of the top and bottom tee. No moment load in the tee (the so-called “secondary” moment) is considered. Thus the tee is “investigated as an axially loaded column”.

Requirement 3.7(a)4 addresses lateral buckling. This requirement is not checked by the program. You should satisfy yourself that this requirement has been satisfied for each opening. For LRFD design the program does use the reduced torsional constant, J, per Equation (3-26), in the design of the beam.

Requirement 3.7(c)2 has an additional requirement for shear connectors, with clarification given in Section 5.7(c)2. The program does not check this requirement, nor does it add additional studs to conform to this requirement. If the number of studs called for by the program are greater than or equal to 2 studs per foot in the region specified in the Design Guide, no additional studs are required; otherwise additional studs in the region specified in the Design Guide should be indicated on the structural drawings.

The effects of web openings on the beam deflection may be significant. However, the approximate procedures given in the design guide are not general enough to universally apply to the opening configurations possible in the program, so no procedures were implemented. Thus the deflections reported by the program do not consider the additional effects of the openings. The engineer may consider applying a more stringent deflection criteria to these beams to account for the fact that the beam may deflect more than reported.

8.17.2 SCI Publication 068

> **Note:** You should familiarize yourself with the requirements of the SCI publication. Important technical information is contained therein that is not repeated here.

Stiffeners are assumed to be placed 12mm clear from the edge of opening. Stiffener welds are assumed to be continuous on both sides of the stiffener plate.

In Section 3 there is a recommendation that the shear strength of the concrete be ignored for edge beams unless the decking and reinforcement are effectively anchored. The program assumes that they are effectively anchored.

SCI Publication 068 includes provisions for notched beams. Those provisions have not been implemented.

The effects of web openings on the beam deflection may be significant. For composite beams with rectangular openings the guidelines of SCI Advisory Desk 183: Deflection of composite beams with large web openings are used. For circular openings, additional deflections are neglected as indicated in that document. As no guidance is given for deflections for precomposite and non-composite beams with rectangular openings, the deflections for such beams is (somewhat) arbitrarily increased by 1/3, regardless of the size or number of rectangular openings. Engineers should satisfy themselves that this is adequate.

Chapter 9

Additional Information

Where to go to get help or learn about related products.

9.1 Technical Support

These resources are provided to help you answer support questions:

- Service Ticket Manager — http://www.bentley.com/serviceticketmanager — Create and track a service ticket using Bentley Systems' online site for reporting problems or suggesting new features. You do not need to be a Bentley SELECT member to use Service Ticket Manager, however you do need to register as a user.
- Knowledge Base — http://appsnet.bentley.com/kbase/ — Search the Bentley Systems knowledge base for solutions for common problems.
- FAQ s and TechNotes — http://communities.bentley.com/Products/Structural/Structural_Analysis___Design/w/Structural_Analysis_and_Design__Wiki/structural-product-technotes-and-faqs.aspx — Here you can find detailed resolutions and answers to the most common questions posted to us by you.
- Ask Your Peers — http://communities.bentley.com/forums/5932/ShowForum.aspx — Post questions in the Be Community forums to receive help and advice from fellow users.

9.2 RAM Structural System

RAM SBeam was extracted from and contains a subset of the design capabilities of the RAM Steel Beam design module of the RAM Structural System.

The RAM Structural System provides tremendous value to the engineer in increased productivity, automating and integrating many tasks that must otherwise be performed

manually by the engineer when using stand-alone programs such as RAM SBeam.

The RAM Structural System automatically computes tributary loads to all members (beams, columns, walls, etc.); reduces the Live Load in accordance with applicable building codes; designs all beams, columns, baseplates and footings from the roof to the base; and performs wind and seismic analysis. Comprehensive calculations, CAD drawings and material take-off quantities can be obtained from the design of the entire structure. The entire structural database is managed by the RAM Structural System.

The RAM Steel Beam design module of the RAM Structural System is capable of selecting Steel Joists and Joist Girders and designing CMC Smartbeams^{TM}, in addition to its ability to design Composite and Non-composite beams. The RAM Concrete design module is capable of designing concrete structures. The RAM Foundation module is capable of designing a wide range of foundation types. RAM Frame is capable of performing Wind and Seismic analyses, providing member force results to the other design modules.

Integration with and links to other RAM and third-party software by the RAM Structural System provide vibration analysis, connection design, sophisticated CAD drawing management, steel and concrete detailing, P/T slab design, mat foundation design and more.

The RAM Structural System allows the engineer to quickly and accurately design entire roof and floor plans, compare alternate design schemes, and easily adapt to design changes during the course of a design project.

For more information, contact:

Bentley Systems, Inc.

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Appendix A

RAM SBeam Tables

This Appendix addresses the format and use of the tables associated with the RAM SBeam program.

Note: The maximum length of any individual line is 178 characters.

A.1 Metal Deck Tables

In order to accurately calculate the properties of the composite section it is necessary to know certain parameters of the metal deck being used. Rather than requiring that these parameters be calculated and input each time the program is run, the program utilizes a database of decks containing the required information. You merely have to select the deck type, by name, and the program automatically uses the proper values.

The metal deck information is used when defining the composite deck and slab information with the Composite dialog . The selection of the deck file to be used is made or changed using the Tables tab in the General Criteria dialog .

Provided with the program are several files containing Deck Types commonly used, with the deck properties required by the program.

- `RAMDECKS.DCK` contains decks commonly used in the United States
- `RAMCAN.DCK` contains decks commonly used in Canada
- `RAMUK.DCK` contains decks commonly used in Great Britain
- `RAMAS.DCK` contains decks commonly used in Australia.

The files are in text format that can be edited, thus allowing the engineer to customize the table to meet current needs. Decks not listed in the original file can be added while decks not

used can be deleted. If desired, generic decks can be created. Deck tables for other countries can be easily created.

Tip: A backup copy of the deck table (file extension `.DCK`) file should be made before editing so that if errors are made, the original file can be recovered.

Rather than modifying the original deck type table, you might prefer to create a new table consisting of the most commonly used decks. A separate file of decks, perhaps for those commonly used in other countries, might be created. There is no limit to the number of deck tables that the program will support. The only criteria that must be met is that the new files be in the prescribed format.

Deck tables may be defined in either English units or SI units. It is not necessary for the units of the deck table to correspond to the current program units; the program will make the appropriate units conversion if necessary. For example, a deck table whose units are English could be selected even though the program units are currently SI, and vice versa.

Tip: The metal deck information is used when defining the composite deck with the Composite dialog. Since deck types in the decks list box are listed in the same order as they appear in the deck table file, moving the most commonly specified deck type to the top of the file will save time modeling since it will always appear first in the list box.

The deck tables must be located in the `Tables` directory.

A.2 Metal Deck Table File Format

Files of user-defined metal decks may be created using a simple text editor. Use spaces, not tabs, between data items. The file name must have the extension `.DCK`.

Warning: Do NOT use a word processor as it might embed control characters into the file.

The file has the following format:

The character in the first line indicates the system of units used in the table: an E indicates English (US Imperial) units and an S indicates SI units.

The fields on each subsequent line of the file describe the Deck Name and its associated properties. Each field is separated by a comma and one or more blanks, in the following format:

```
Deck Name, Hr, RibSpacing, Wr, AcRib, Ybar
```

where:

Deck Name
: the name of theHr deck type (20 alphanumeric character or less).

Hr

the nominal rib height (in. or mm).

RibSpacing

the rib spacing (in. or mm).

Wr

the average width of concrete rib (in. or mm).

AcRib

the area of concrete in the rib per foot or per meter of deck width (in.²/ft. or cm²/m).

> **Note:** This value is used only for AISC ASD section properties and for BS 5950 transverse reinforcement calculation, and may be left blank otherwise.

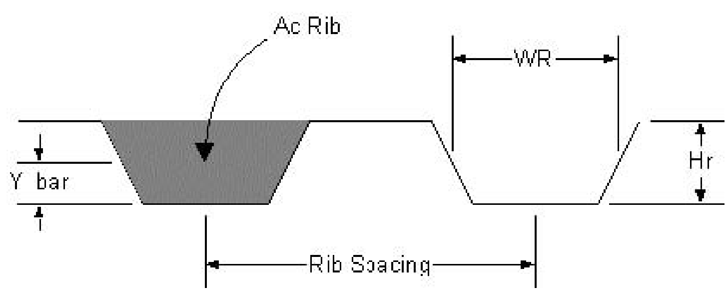
Ybar

the distance from the bottom of the deck to the centroid of the concrete area AcRib (in. or mm).

> **Note:** This value is used only for AISC ASD, and may be left blank otherwise.

Hr and Wr are used to calculate the allowable shear stud values per Chapter I of AISC Manual of Steel Construction (ASD and LRFD), Clause 17.7 of CAN/CSA-S16-01, Clause 5.4.7 of BS 5950: Part 3: Section 3.1: 1990 or Clause 6.6 of Eurocode EN 1994 1-1. Rib Spacing is used to determine the practical spacing and number of studs along a beam. Hr, AcRib, and Ybar are used to calculate the transformed section moduli. See the following figure. Note that even though the figure seems to indicate that AcRib is the area of concrete in one rib, AcRib is actually the area of concrete in the rib per one foot of deck width if in English units, or per one meter of deck width if in SI units. For example, if the table is in English units and the ribs are spaced 12" on center, AcRib is equal to the area of concrete in one rib; if the ribs are spaced 9" on center, AcRib is equal to the concrete in 1.333 ribs (1.333 = 12.0 / 9.0).

Figure A-1: Deck cross sectional properties



The following is an example listing of a `RAMDECKS.DCK` file:

```
E
ASC 3W, 3.0, 12.0, 6.0, 18.0, 1.604
ASC 2W, 2.0, 12.0, 6.0, 12.0, 1.056
ASC -24 HiForm, 3.0, 8.0, 2.312, 10.406, 1.568
ASC B-36 HiForm, 1.5, 6.0, 2.062, 6.188, 0.788
```

```
USD 3" Lok-Floor, 3.0, 12.0, 6.0, 18.0, 1.583
USD 2" Lok-Floor, 2.0, 12.0, 6.0, 12.0, 1.056
USD 1.5" Lok-Floor, 1.5, 12.0, 6.0, 9.0, 0.792
USD B-Lok, 1.5, 6.0, 2.25, 6.375, 0.794
VERCO W3 Formlok, 3.0, 12.0, 6.0, 18.0, 1.625
VERCO W2 Formlok, 2.0, 12.0, 6.0, 12.0, 1.056
VERCO B Formlok, 1.5, 6.0, 2.125, 6.375, 0.794
VULCRAFT 3.0VL, 3.0, 12.0, 6.0, 18.0, 1.604
VULCRAFT 2.0VL, 2.0, 12.0, 6.0, 12.0, 1.056
VULCRAFT 1.5VL, 1.5, 6.0, 2.125, 6.375, 0.794
WHEELING 3.0SB, 3.0, 12.0, 6.0, 18.0, 1.583
WHEELING 2.0SB, 2.0, 12.0, 6.0, 12.0, 1.056
WHEELING 1.5SB, 1.5, 6.0, 2.032, 6.095, 0.808
WHEELING 1.5SBR, 1.5, 6.0, 3.968, 11.90, 1.104
Flat Slab, 0.0001, 0.0001, 1.0, 0.0, 0.0
```

A.3 Master Steel Tables

Contain all of the section properties for each available section. The program accesses these tables to gather information for calculations.

Several Master Steel Tables are provided with the program:

- `RAMAISC.TAB` contains the AISC shapes, including the shapes with the HSS designations.
- `RAMAISCM.TAB` is identical to `RAMAISC.TAB` except that it contains the metric labels of the AISC shapes.
- `RAMCAN.TAB` contains the Canadian shapes.
- `RAMUK.TAB` contains the British shapes.
- `RAMUK_CF.TAB` contains the standard UB and UC shapes, like the `RAMUK.TAB`, but it contains the cold-formed hollow structural sections rather than the hot finished hollow sections.
- `RAMEURO.TAB` contains the European shapes.
- `RAMARCELOR.TAB` contains the ArcelorMittal shapes.
- `RAMAS.TAB` contains the Australian shapes.

The Master Steel Tables are in text file format and can be edited, allowing you to customize the tables. Steel sections are listed in groups according to their shape. Sections not included in the original files can be added and those that are not used can be removed. When removing sections, keep in mind that any section that appears in a Design Steel Table must also appear in the corresponding Master Steel Table. The converse of this is not true. The Master Table can contain sections that do not appear in other tables. Besides adding and deleting sections, groups and sections within groups can be reordered in any way the engineer finds convenient.

> **Tip:** It is recommended that edited files be given different names than the original files to distinguish them from the originals. Otherwise, a backup copy of the file should be made before editing so the original file can be recovered if desired.

Additional Master Steel Tables can be created to contain specially designed built-up sections or other sections not included in one of the Master Tables. There is no limit to the number of tables supported by the program. If new Master Tables are created, corresponding Design Tables must also be created.

A.4 Master Steel Table File Format

> **Note:** The Master Steel Tables are used jointly by both RAM SBeam and the RAM Structural System. The description given below also includes information on shapes used by the RAM Structural System, but *only I-shapes, Channels and TS (HSS) are relevant to RAM SBeam*. Only the desired relevant shapes need to be included in the Master Table.

New Master Steel Tables can be created using a simple text editor. Use spaces, not tabs, between data items. The file name must have the extension `.TAB`.

> **Warning:** Do NOT use a word processor as it might embed control characters into the file.

The file has the following format. The data for a given section must be placed on a single line.

The first line of the file contains an E or S, indicating English or SI units.

The steel sections are then listed, grouped by shape. Each group begins with a header (I, Channel, L, TS, Pipe, Tee, Roundbar, or Flatbar). W, M, and S shapes are included in the “I” group. Single angle properties are used for single angles as well as to calculate the double angle properties. Square and Rectangular Hollow Sections are included in the “TS” group. Round Hollow Sections are included in the “Pipe” group. Single angle, Tee, Round bar and Flat bar shapes are applicable only to braces.

For each group a section is created. Each section begins with a heading and is followed by lines containing the section properties of members of that group, one line per member. Each group has the format seen in the example below, where:

Desig
: the shape designation (e.g., W18X35), 15 characters maximum.

RollFlg
: a flag, either an R or a B, indicating Rolled or Built-up shape. By placing this flag with each section rather than at the beginning of the table, you can mix Rolled and Built-up shapes in the same Master Table.

Depth
: the total depth of the section (in. or mm). Tw is the web thickness (in. or mm).

Bf_{top}
: the top flange width (in. or mm).

Tf_{top}
: the top flange thickness (in. or mm).

Bf_{bot}
: the bottom flange width (in. or mm).

Tf_{bot}
: the bottom flange thickness (in. or mm).

K_{top}
: the distance from the outer face of the top flange to the web toe of the fillet (in. or mm).

K_{bot}
: the distance from the outer face of the bottom flange to the web toe of the fillet (in. or mm).

Area
: the total area (in.^{2} or cm^2).

Ix
: the moment of inertia about the X-X axis. (in.^{4} or cm^4).

Sx_{top}
: the elastic section modulus with respect to the top flange of the member (in.^{3} or cm^3).

> **Note:** This is Zx in European terminology.

Sx_{bot}
: the elastic section modulus with respect to the bottom flange of the member (in.^{3} or cm^3).

> **Note:** This is Zx in European terminology.

Zx
: the plastic section modulus of the member (in.^{3} or cm^3).

> **Note:** This is Sx in European terminology.

Iy
: the moment of inertia about the Y-Y axis (in.^{4} or cm^4).

Sy
: the elastic section modulus of the member with respect to the Y-Y axis (in.^{3} or cm^3).

> **Note:** This is Zy in European terminology.

Zy
: the plastic section of the member with respect to the Y-Y axis (in.^{3} or cm^3).

This is Sy in European terminology.

J
: the Torsional Constant (in.^{4} or cm^4)

Cw

the Warping Constant (in.^{6} or cm^6).

RT_{top}

the radius of gyration (see AISC Manual) with respect to the top flange of the member (in. or mm).

> **Note:** This is used only for AISC ASD and may otherwise be left blank.

RT_{bot}

the radius of gyration (see AISC Manual) with respect to the bottom flange of the member (in. or mm).

> **Note:** This is used only for AISC ASD and may otherwise be left blank.

A.4.1 For Channels

xbar is the distance from the web face to the centroid with respect to the Y-Y axis (in. or mm).

eo is the distance from the web face to the shear center (in. or mm).

A.4.2 For Angles (Ls)

Vleg is the vertical leg width (in. or mm).

Hleg is the horizontal leg width (in. or mm).

tLeg is the leg thickness (in. or mm).

A.4.3 For Pipes (Round Hollow Sections)

OutDia is the outer diameter of the member (in. or mm).

Tw is the wall thickness. I is the moment of inertia of the member (in.^{4} or cm^4).

S is the section modulus of the member (in.^{3} or cm^3).

Z is the plastic section of the member (in.^{3} or cm^3).

```
I
Desig RollFlg Depth Tw Bftop Tftop Bfbot Tfbot ktop kbot
Area Ix Sxtop Sxbot Zx Iy Sy Zy J Cw RTtop RTbot
Channel
Desig Rollflg Depth Tw Bftop Tftop Bfbot Tfbot ktop kbot
Area Ix Sxtop Sxbot Zx Iy Sy Zy J Cw xbar e0
L
Desig RollFlg Vleg Hleg tleg Area Ix Sx Zx Iy Sy Zy J Cw
TS
Desig RollFlg Depth Tw Bf Tf Area Ix Sx Zx Iy Sy Zy J
Pipe
Desig RollFlg OutDia Tw Area I S Z
```

```
Tee
Desig RollFlg Depth Tw Bftop Tftop ktop Area Ix Sxtop Sxbot
Zx Iy Sy Zy J Cw
RoundBar
Design Diameter Area
FlatBar
Desig RollFlg Bf Tf Area
```

Note: The section properties of any given member must appear on a single line in the Master Steel Table File. Some shapes are shown above in two lines due to space limitations on the page.

It is not necessary to specify values for the italicized variables in the format list. If any of the italicized values in the format list are set equal to zero or are left blank, those values will be calculated based on the dimensions given for the web and flanges except as explained below.

If Bf_{bot} is set equal to zero in the table, Bf_{bot} will be set equal to Bf_{top}.

If Tf_{bot} is set equal to zero in the table, Tf_{bot} will be set equal to Tf_{top}.

If Sx_{bot} is set equal to zero but Sx_{top} is not equal to zero, Sx_{bot} will be set equal to Sx_{top}. If Sx_{top} and Sx_{bot} are both set equal to zero, Sx_{bot} will be calculated based on the dimensions given for the web and flanges.

For angles, if Hleg is set equal to zero, Hleg will be set equal to Vleg.

When zeros occur between non-zero values on a data line, the zeros must appear on the data line. If a zero occurs and ALL fields to the right also contain zeros, those zeros may be removed and the remainder of the line left blank.

Since the actual section properties for rolled shapes are larger, due to the contribution of the fillets, than would be calculated based strictly on the web and flange dimension, some increase in accuracy can be obtained in the design by specifying all of the section properties in the tables.

The following is a sample listing from the `RAMAISC.TAB` file:

```
E
I
W44X285 R 44.02 1.025 11.810 1.770 0. 0. 2.6875 0. 83.80
24600.0 1120.00 0. 1310.00 490.0 83.00 135.000 60.00
219000.0 2.95 0.
W44X248 R 43.62  .865 11.810 1.575 0. 0. 2.5000 0. 72.80
21400.0 983.00 0. 1150.00  435.0 74.00 118.000 40.70
192000.0 2.96 0.
.
.
.

Channel
```

```
C15X50   R 15.0 .716 3.716 .650 0. 0. 1.4375 0. 14.70 404.00
53.80 68.20 11.000 3.780 8.170 2.67  492.00  .798  .583
C15X40   R 15.0 .520 3.520 .650 0. 0. 1.4375 0. 11.80 349.00
46.50 57.20  9.230 3.370 6.870 1.46  411.00  .777  .767
.
.
.

L
L8X8X1-1/8    R 8.0 8.0 1.1250 16.700 98.000 17.500 31.600
98.000 17.500 31.600 7.13000 32.50000
L8X8X1        R 8.0 8.0 1.0000 15.000 89.000 15.800 28.500
89.000 15.800 28.500 5.08000 23.40000
.
.
.



TS
HSS16X16X5/8    R 16.0 0.581 16.0 0.581 35.0 1370.  171.
200.  1370.  171.  200.   2170.
HSS16X16X1/2    R 16.0 0.465 16.0 0.465 28.3 1130.  141.
164.  1130.  141.  164.   1770.
.
.
.

PIPE
HSS20.000X0.500 R 20.000  0.465  28.5  1360   136    177
HSS20.000X0.375 R 20.000  0.349  21.5  1040   104    135
HSS18.000X0.500 R 18.000  0.465  25.6   985   109    143
.
.
.
TEE
WT22X167.5 R 22.0 1.02 16.0 1.77 2.56 49.1 2160 392.0 131
233 600 75.3 118 15400 117.0
WT22X145   R 21.8 0.87 15.8 1.58 2.37 42.9 1840 349.1 111
197 523 66.1 103 10700  74.8
.
.
.
ROUNDBAR
RB1/4   0.2500
RB5/16  0.3125
RB3/8   0.3750
.
.
.
```

```
FLATBAR
FB3/16X1/2  R  0.50  0.1875
FB3/16X3/4  R  0.75  0.1875
FB3/16X1    R  1.00  0.1875
```

Note: The section properties of any given member must appear on a single line in the Master Steel Table File. Several members are shown above in two lines due to space limitations.

In addition to the standard rolled steel shapes, tables of built-up shapes can be created. Below is a portion of a file of built-up shapes. Notice that in this example, only the web and flange dimensions are included. If other section properties are not included in the file the program will calculate the section properties from the given data.

```
E
I
.
.
.
B14X19.2  B  13.75  0.188  4.25  0.375
B17X19.3  B  16.63  0.188  4.25  0.250  4.25  0.375
B12X19.3  B  11.63  0.188  4.25  0.250  6.75  0.375
B15X19.6  B  14.63  0.188  4.25  0.250  5.25  0.375
B10X19.8  B   9.75  0.188  5.50  0.375
B16X20.2  B  15.63  0.188  4.25  0.250  5.50  0.375
B15X20.2  B  14.63  0.188  4.25  0.250  4.25  0.375
B14X20.4  B  13.50  0.250  5.50  0.250
B18X21.7  B  17.50  0.250  4.25  0.250
.
.
.
```

A.5 Design Steel Tables

Contain listings of shapes without section properties. These tables are used to indicate which sizes are to be considered in design.

The Design Steel Tables can be modified by adding, deleting or re-ordering members. When adding new members, it is important to keep in mind that all members in the Design Steel Tables must also be listed in the Master Steel Tables. If members are deleted from Design Steel Tables it is NOT necessary to delete them from the Master Steel Tables.

Table A-4 lists the Master Steel Tables provided with RAM SBeam, the shapes they contain and the units in which the section properties are listed. Table A-5 lists the Design Steel Tables provided with RAM SBeam, the shapes they contain and their corresponding Master Steel Table.

Several Beam Design Steel Tables are included with the RAM SBeam program (see Table A-5). In these tables, sections are grouped into I-shaped members, Square and Rectangular Hollow Sections and Channels. Within the groups, sections are sorted by weight in ascending order. When the program selects the optimal beam, it starts at the top of the file and works it way down until it finds the first beam that satisfies all criteria. While the order of the groups and the order of sections within groups can be re-ordered, the program's selection scheme should be kept in mind when doing so.

Tip: It is recommended that edited files be given different names than the original files to distinguish them from the originals. Otherwise, a backup copy of the file should be made before editing so the original file can be recovered if desired.

Table A-1: RAM SBeam Steel Master Tables

Table Name	Shapes Contained	Units
RAMAISC.TAB	AISC shapes: W, M, S, C, MC, L, HSS, WT, MT, ST, Flat bar, Round bar	English
RAMAISCM.TAB	AISC shapes, metric equivalent of RAMAISC.TAB	English
RAMCAN.TAB	Canadian shapes	SI
RAMUK.TAB	British shapes	SI
RAMUK_CF.TAB	British shapes, identical to RAMUK.TAB except with cold-formed hollow structural sections	SI
RAMARCELOR.TAB	ArcelorMittal European shapes: IPE, IPN, HE, HL, HD, HP, W, UAP, UPE, UPN, U, UE, L, Flat bar, Round bar	SI
RAMAS.TAB	Australian shapes	SI

Table A-2: Beam Design Tables

Table Name	Shapes Contained	Master Table
RAMAISC.BMS	AISC shapes: W, M, C, MC, HSS	RAMAISC.TAB
RAMS.BMS	AISC S-shapes	RAMAISC.TAB
RAMAISCM.BMS	AISC shapes, metric equivalent to RAMAISC.BMS	RAMAISCM.TAB

Table Name	Shapes Contained	Master Table
RAMSM.BMS	AISC S-shapes, metric equivalent to RAMS.BMS	RAMAISCM.TAB
RAMCAN.BMS	Canadian shapes: W, C, HS	RAMCAN.TAB
RAMCANWF.BMS	Canadian WWF shapes	RAMCAN.TAB
RAMUK.BMS	British shapes: UB, C, SHS, RHS	RAMUK.TAB
RAMUK_CF.BMS	British shapes: UB, C, cold-formed SHS, cold-formed RHS	RAMUK_CF.TAB
RAMARCELOR.BMS	ArcelorMittal European shapes: IPE, IPN, HE, HL, HD, HP, W, UAP, UPE, UPN, U, UE	RAMARCELOR.TAB
CORUSADV.BMS	Corus Advance shapes: UKB, UKC, UKPFC	RAMUK.TAB
RAMAS.BMS	Australian Shapes: UB, UC, WB, WC, PFC	RAMAS.TAB

In addition to modifying the existing tables, new Design Steel Tables can be created. When creating new tables, it is imperative that they be created in the same format as the original tables. There is no limit to the number of tables that the RAM SBeam can support.

The tables may be in either English (US Imperial) or SI units.

The tables must be located in the Tables directory.

A.6 Beam Design Steel Table Format

Files of beam shapes to be used by the program may be created and modified. Use spaces, not tabs, between data items. The file name must have the extension `.BMS`.

> **Warning:** The file must be edited using a simple text editor, not a word processor as it might embed control characters into the file.

The file has the following format:

The first line is an optional comment line indicating which Master Table is to be used in conjunction with the Design Table.

The section groups follow. Groups are separated by a blank line. Each section begins with a heading with the following format:

```
Group
```

where:

Group is the Group Shape (I indicates I-beams, TS indicates TS and Square and Rectangular Hollow sections, and Channel indicates Channels).

Each subsequent line has the following format:

```
Label Flag
```

where:

Label
: the member size (e.g. W8x10).

Flag
: Flag is a single character that indicates how the program will consider the member:

  / indicates that the size is to be ignored. It has the same effect as deleting the member from the table.

  *indicates that the size is considered a "common" size. When selecting the optimum beam size the program investigates only the asterisked sizes when designing simple composite beams, or when designing any beam when the criteria "Check Unbraced Length" is not selected, unless there is a beam depth restriction. This speeds up the design of beams significantly because it allows the program to ignore unusual sizes when designing for simple conditions. Thus, when the table is to be used to design such members, at least some of the sections must have an asterisk. In the `RAMAISC.BMS` table supplied with the program, the asterisked sizes are those shown in bold in the "Allowable Stress Design Selection Table - Sx" and "Load Factor Design Selection Table – Zx" tables in the AISC manual.

  +indicates that the size is to be considered in optimization except as explained for "*".

When there is a depth restriction or an unbraced length consideration the program investigates sizes flagged by either a plus sign or an asterisk until an acceptable size is found. The plus symbol should be used for any sizes (e.g., small sizes) that the you do not want designed as composite beams.

The order in which the members are listed is critical to the proper performance of the program. The members must be listed in the optimum order (least expensive, generally least weight), beginning with the smallest member and ending with the largest member. The program selects the first member it encounters that satisfies all design requirements and constraints.

If there is no size in the table which satisfies all of the design criteria and requirements for a given member, the program will indicate No Design on the output, View/Update, and on-screen. You must then take whatever action is appropriate.

The file may contain 2000 member sizes.

The following is a sample listing from the `RAMAISC.BMS` file:

```
;MasterTable=RAMAISC.TAB
I
.
.
.
W6X9   /
M12X10 /
W8X10  *
M12X10.8 /
M12X11.8 /
W10X12 *
W6X12  /
W8X13  +
.
.
.

Channel
C3X4.1    /
C3X5      /
C4X5.4    +
C3X6      /
MC10X6.5  +
C5X6.7    +
.
.
.

TS
HSS2X1X1/8      /
HSS3X1X1/8      /
HSS2.5X1.5X1/8  /
HSS2X1X3/16     /
.
.
.
```

A.7 Smartbeam Tables - Castellated

A table of CMC (formerly SMI) castellated Smartbeams, called `RAMSMI.CAS`, is provided with the program. Although tables can be created and edited by the user, it is not recommended that the user modify the RAMSMI.CAS table unless directed by the manufacturer, CMC. The

file name must have the extension `.CAS`.

> **Warning:** Do NOT use a word processor as it might embed control characters into the file.

> **Note:** The format for the castellated Smartbeams is different than that of the cellular Smartbeams.

The file has the following format:

The first line contains an E or S, indicating English or SI units.

The Smartbeam sections are then listed in the following format:

```
Label TopSize BotSize emin emax dtmin dtmax dtstandard flag
```

where:

Label
: the designation for the castellated Smartbeam (e.g., CB18x14).

TopSize
: the label of the wide-flange section used for the top (e.g.,W12 X14).

BotSize
: the label of the wide-flange section used for the bottom (e.g., W12X16).

emin
: the minimum e to be considered.

emax
: the maximum e to be considered.

dtmin
: the minimum dt to be considered.

dtmax
: the maximum dt to be considered.

dtstandard
: the standard (ideal) dt to be considered.

flag
: a single character used to indicate whether the member is to be considered for composite or noncomposite design:

  "-" means consider for noncomposite only,

  "*" means consider for composite only,

  "+" means consider for composite or noncomposite, and

  "/" means do not use (used to remove a size from consideration without actually deleting it from the table).

Each label must be unique (i.e., the same label can't appear twice in the table) and it is limited to a maximum of 15 characters.

The sections must be listed in order of cost, least expensive first (generally the lightest). RAM SBeam Design selects the first member in the table that satisfies all design requirements and constraints.

The values of emin, emax, dtmin, and dtmax are used by the program to limit the number of hole configurations that are considered.

The following is a sample listing from the `RAMSMI.CAS` file:

```
E

CB12x10 W8x10 W8x10 3.0 5.000 1.750 2.875 2.25 +

CB15x12 W10x12 W10x12 3.0 5.625 1.875 3.125 2.50 +

CB12x13 W8x13 W8x13 3.0 6.875 1.750 2.875 2.25 +

CB15x12/15 W10x12 W10x15 3.0 5.625 1.875 3.125 2.50 *

CB18x14 W12x14 W12x14 3.0 6.000 2.250 3.750 3.00 +

CB15x12/17 W10x12 W10x17 3.0 5.625 1.875 3.125 2.50 *

CB15x15 W10x15 W10x15 3.0 6.875 1.875 3.125 2.50 +

CB12x15 W8x15 W8x15 3.0 7.250 1.750 2.875 2.25 +

CB18x14/16 W12x14 W12x16 3.0 6.000 2.250 3.750 3.00 *

.

.

.
```

A.8 Smartbeam Tables - Cellular

A table of CMC (formerly SMI) cellular Smartbeams, called `RAMSMI.CEL`, is provided with the program. Although tables can be created and edited by the user, it is not recommended that the user modify the `RAMSMI.CEL` table unless directed by the manufacturer, CMC. Use spaces, not tabs, between data items. The file name must have the extension `.CEL`.

> **Warning:** Do NOT use a word processor as it might embed control characters into the file.

> **Note:** The format for the cellular Smartbeams is different from that of the castellated Smartbeams.

The file has the following format:

The first line contains an E or S, indicating English or SI units.

The Smartbeam sections are then listed in the following format:

```
Label TopSize BotSize Dostandard flag
```

where:

Label
the designation for the cellular Smartbeam (e.g., LB18x14).

TopSize
the label of the wide-flange section used for the top (e.g.,W12 X14).

BotSize
the label of the wide-flange section used for the bottom (e.g., W12X16).

Dostandard
the standard (ideal) hole diameter Do to be considered.

flag

a single character used to indicate whether the member is to be considered for composite or noncomposite design:

"-" means consider for noncomposite only,

"*" means consider for composite only,

"+" means consider for composite or noncomposite, and

"/" means do not use (used to remove a size from consideration without actually deleting it from the table).

Each label must be unique (the same label can't appear twice in the table) and it is limited to a maximum of 15 characters.

The sections must be listed in order of cost, least expensive first (generally the lightest). RAM SBeam Design selects the first member in the table that satisfies all design requirements and constraints.

The following is a sample listing from the `RAMSMI.CEL` file:

```
E

LB12x10 W8x10 W8x10 7.500 +

LB15x12 W10x12 W10x12 10.000 +

LB12x13 W8x13 W8x13 7.500 +
```

```
LB15x12/15 W10x12 W10x15 10.000 *

LB18x14 W12x14 W12x14 12.000 +

LB15x12/17 W10x12 W10x17 10.000 *

LB15x15 W10x15 W10x15 10.000 +

LB12x15 W8x15 W8x15 7.500 +

LB18x14/16 W12x14 W12x16 12.000 *

LB15x12/19 W10x12 W10x19 10.000 *

.

.

.
```

Appendix B

Bison Precast Units

The capability to design composite beams with Bison precast units has been incorporated in RAM SBeam.

Bison Concrete Products Limited is the largest producer of precast concrete floors in the United Kingdom. The use of Bison Hollowcore and solid prestressed slabs, composite with the structural steel, is a common construction technique. There are a number of advantages to using Bison precast planks: a reduction in the total tonnage of structural steel, erection speed and reduced site operations, among others.

A brief description of the design capabilities follows. Except as noted, the design features and capabilities of the program using Bison precast units are the same as those using any other composite deck. Contact Bison for more information on the use of Bison precast units.

B.1 To define Bison precast unit decks

Used to specify Bison hollowcore or Bison solid plank decks for UK beam design.

Bison Hollowcore and Bison Solid Plank have been added to the file of decks available in the UK. Select the `RAMUK.DCK` file as the Deck Table in the General Criteria dialog Tables tab in order to make these decks available for use.

1. Select **Beam** > **Composite**.
   The Composite dialog Decking tab opens.
2. Select the desired Bison product from the list of Decks.
3. Specify the desired stud and concrete properties.

> **Note:** The concrete properties are those of the insitu concrete, not those of the precast concrete. Also note that the value to be input for Concrete Thickness (Total)

should include the overall thickness of the plank plus topping slab, if any. The insitu concrete is always assumed to be normal weight concrete.

4. Click **OK**.
   The deck data is updated and the dialog closes.

B.2 Criteria

Criteria used in the design of composite beams with Bison plank is specified using the Design Criteria dialog Bison PC Units tab.

Note: Since this feature has only been implemented for the UK, the code selection in the Design Criteria dialog must be BS 5950.

In this dialog, there are three sections: Gap Data, Transverse Reinforcement and Precast Units. Only the Gap Data may be directly specified; the other two sections are for informational purposes only, indicating values that the program will assume and use.

The Gap is the distance between the ends of the precast units (refer to the following Technical Notes for additional detail). It affects the effective width of compression area of concrete and the stud capacity. It is a function of the beam flange width, the required width of bearing of the precast unit on the steel beam, the construction tolerance of the precast units and the construction and erection tolerance of the structural steel. Generally, the Bearing Width is 40mm, the Slab Tolerance is 20mm and the Construction Tolerance is 15mm.

B.3 Technical Notes

Engineering reference material on using Bison Precast Units.

B.3.1 Precast Units

Composite design can be carried out using either Bison Hollowcore or Bison Solid Plank.

If the precast unit type is Solid Plank, the beam can be designed compositely for any angle of beam to plank. The values of effective width of compression area, beff, and the shear stud capacity, Qp, are calculated regardless of orientation.

If the precast unit type is Hollowcore, the beam can only be designed compositely if the angle between beam and plank is greater than or equal to 30 degrees. If it is less than that angle, the beam is designed non-compositely.

If Hollowcore deck is perpendicular (greater than 30 degrees) to the beam on one side and parallel (less than 30 degrees) to the beam on the other, the beam is designed as for deck on one side only, with beff taken as one-half of the normally calculated beff plus six stud diameters.

If there is a regular composite deck on one side and Bison precast units on the other, the contribution of the Bison precast units to the effective section is ignored and the beam is designed as a regular composite beam with deck on one side only.

If the plastic neutral axis is in the concrete, the beam is rejected and a different size selected. Current research is not valid when the plastic neutral axis is in the concrete.

The program does not select the required precast unit; that must be done by the Engineer based on a number of criteria such as loading, fire resistance, etc. Contact Bison for information regarding the selection of precast units. Reprints of Load/Span tables for various profiles, from Bison literature, are included in the Appendix herein for your convenience.

Note: The weight of the plank and insitu concrete must be included in the loads you assign to the model.

B.3.2 Gap

The gap is calculated as follows:

gap = Flange Width - 2(Bearing Width) - Slab Tolerance - Construction Tolerance

where:

Flange Width is the width of the top flange of the beam,

Bearing Width and Slab Tolerance are as specified in the Design Criteria dialog, and

Construction Tolerance is the greater of the value specified in the Design Criteria dialog and Span/1000.

The minimum allowable gap is 30mm. If the calculated gap is less than that value the beam size is rejected and a beam with a wider flange width is selected.

Note: The minimum allowable flange width is 165mm. If the top flange is less than that the beam size is rejected and a beam with a wider flange width is selected.

B.3.3 Effective Width of Compression Area

The effective width of compression area for an interior beam is calculated as follows:

$$beff = \left[\left(\frac{\phi}{16}\right)\left(\frac{fy}{460}\right)\left(\frac{300}{s}\right)\left(\frac{40}{fcu}\right)\right]^{0.3333} * 1000 + 2.5g$$

where:

ϕ = transverse reinforcement diameter (program assumes 16mm),

fy = reinforcement strength (program assumes 460 N/mm²),

s = bar spacing (program assumes 300mm),

fcu = concrete strength for the insitu concrete (as specified, generally 30 N/mm²),

g = gap, not to exceed 100 mm

beff is limited by distance to adjacent beams, slab edges or openings and by span / 4, if appropriate. For edge beams the contribution of the edge to beff is the lesser of the slab edge distance and six stud diameters. If Hollowcore slab is being used and it is parallel to the beam on one side, the contribution of that side to beff is equal to six times the stud diameter.

B.3.4 Shear Stud Capacity

The design shear resistance, Qp, of the studs is calculated in the following way. First, P_{RD} is calculated based on the Eurocode methodology and is taken as the lesser of the following:

$P_{RD} = 0.8\ fu\ (\pi\ d^2 / 4) / \gamma_v$

$P_{RD} = 0.29\ \alpha\ \beta\ \varepsilon\ d^2 Ö(\omega\ fcp\ Ecp) / \gamma_v$

where:

fu = ultimate tensile strength of the stud as specified in the Composite dialog Deck tab (N/mm^2)

d = stud diameter

γ_v = partial safety factor (1.25)

$\alpha = 0.2\ (h / d + 1.0) \leq 1.0$

where:

h = stud height

$\beta = 0.5\ (g / 70.0 + 1.0) \leq 1.0$

where:

g = gap ≥ 30mm

$\varepsilon = 0.5\ (\phi / 20.0 + 1.0) \leq 1.0$

where:

ϕ = reinforcement diameter ≥ 8mm

$\omega = 0.5\ (w / 600.0 + 1.0) \leq 1.5$

where:

w = width of precast unit

fcp = average concrete strength fcu of the insitu and precast concrete

Ecp = average value of elastic modulus of the insitu and precast concrete

Qp is then taken as the lesser of P_{RD} and the capacity allowed per BS 5950.

Note: Only one row of studs is allowed.

B.4 Contact

For more information on Bison concrete products, contact Bison directly.

Bison Concrete Products Limited

Millennium Court

First Avenue, Centrum 100

Burton Upon Trent, DE14 2WR

FAX 01283 544900

TEL 01283 495000

E-mail concrete@bison.co.uk

Website www.bison.co.uk

Appendix C
Steel and Synthetic Fibers

The program can consider the contribution of fibers in reducing or eliminating the need for traditional transverse reinforcing for UK standards.

This feature is only available in the UK and where Kingspan floor decks reinforced with Dramix Fibers or Corus floor decks reinforced with FibreFlor are available. It is not available in the United States.

Composite slabs traditionally have been constructed using top mesh reinforcement to resist cracking of the slab surface and to provide the tensile strength for the condition where the strength of the deck is reduced when directly exposed to the heat of a fire. In some cases, conventional reinforcement can be replaced with steel and synthetic Fibers.

Fibers may be used in lieu of, or in addition to, traditional reinforcing such as mesh. It can be mixed in the concrete at the concrete batching plant to provide a pre-reinforced concrete without the need for mesh reinforcement to be installed on site. This gives many advantages at the construction stage over the traditional mesh reinforced composite slab.

RAM SBeam does not perform an investigation of fire rating requirements.

C.1 Dramix

Dramix RC-65/60-BN steel Fibers produced by Bekaert Building Products Ltd may be used in conjunction with Kingspan Multideck 50, 60 and 80 for slab reinforcement.

Kingspan Metl-Con Limited and Bekaert Building Products Ltd have worked together to develop and test the use of Dramix fibre reinforced concrete with Kingspan Multideck 50, 60 and 80 deck products to produce an economic composite slab solution. Test work has been carried out and the data analyzed by the Steel Construction Institute to establish the feasibility of constructing composite slabs and beams with Multideck floor deck and Dramix steel fibre concrete.

Contact Kingspan Metl-Con Limited and/or Bekaert Building Products Limited for more information on the use of Dramix steel fibers.

C.2 FibreFlor

FibreFlor is the name given to ComFlor slabs reinforced with Propex fibers. It may be used in conjunction with Corus ComFlor 46, 51, 60 and 80.

Test work has been carried out and the data analyzed by the Steel Construction Institute to establish the feasibility of constructing composite slabs and beams with Corus floor deck and FibreFlor.

Contact Corus for more information on the use of FibreFlor.

This feature is also available for Tegral ComFlor slabs.

C.3 To specify fibers in the floor system

Used to specify fiber reinforcement composite floors for UK beam design.

The option to use Dramix Steel Fibers is only available when the `RAMUK.DCK` deck table is selected on the General Criteria dialog Tables tab .

1. Select **Beam** > **Composite...**.
   The Composite dialog Decking tab opens.
2. For the **Deck Type**, select either
   Kingspan Multideck 50, 60 or 80 decks
   or
   Corus or Tegral ComFlor 43, 51, 60 or 80 decks

   Note: Both sides of the beam must have the same type of decking selected.

   The option for **Reinforced with Dramix Steel Fibers** (Kingspan) or **Reinforced with FibreFlor** (Corus or Tegral) option appears above the table.
3. Select the option for **Reinforced with Dramix Steel Fibers / FibreFlor**.
4. Modify any other decking parameters as necessary.

   When Dramix Steel Fibers are specified, the density of concrete used in the calculation of floor loads should be increased by 24 kg/m³ for normal weight and by 26 kg/m³ for light weight concrete. When FibreFlor is specified, the density of concrete used in the calculation of floor loads should be increased as appropriate.
5. Click **OK**.

   When the fibre option is selected, the deck label will so indicate. For example, if Kingspan Multideck 60 and Dramix are specified, the deck label will be listed as "Kingspan Multideck 60 + Dramix".

   The dialog closes and the composite deck definition is updated to include fiber reinforcement.

C.4 Deck Table

Kingspan Multideck properties and Corus and Tegral ComFlor properties are included in the `RAMUK.DCK` deck table.

See Metal Deck Tables and Metal Deck Tables File Format for more information on deck tables.

Warning: The program will search for the text strings "Kingspan MD" when determining whether or not to make the Dramix option available, and for "Corus ComFlor" or "Tegral ComFlor" when determining whether or not to make the FibreFlor option available. This means that if the user edits the `RAMUK.DCK` file and changes those portions of the name of the Kingspan, Corus or Tegral decks in any way, the option will not be available.

C.5 Composite Beam Design

Using Steel and Synthetic fibers with a composite floor system.

Fibres are only considered when BS 5950 is selected as the code to be used for beam design.

RAM SBeam does not consider the requirements of reinforcing necessary to satisfy the fire rating. Additional reinforcing may be required as determined by the Engineer. Additional reinforcing may also be required for the proper design of the slab itself for the given spans and loads; RAM SBeam does not design the slab itself, it only uses the slab properties in the design of composite beams.

C.5.1 Dramix

It is assumed that the dosage is 30 kg/m^3 and that the design strength, fy, of the fibres is 900 N/mm^2.

At a dosage of 30 kg/m^3, the fibres provide a reinforcement area equal to 0.37% of the concrete area. The contribution of the fibres to the longitudinal shear capacity when determining the Transverse Reinforcing is given by:

0.7 Asv fy = 0.7 (0.0037 Acv) 900

where Acv is the area of the concrete. When the deck is parallel to the beam, Acv only includes the area of concrete above the deck, but when the deck is perpendicular to the beam Acv includes the area within the deck rib. If the deck is parallel on one side of the beam and perpendicular on the other, the area of the concrete within the rib will be ignored when calculating the required transverse reinforcing for the side with deck parallel and will include the area of the concrete within the rib when calculating the required transverse reinforcing for the side with deck perpendicular.

The contribution of Dramix in resisting the longitudinal shear is considered concurrently with the contribution of any conventional reinforcement, concrete and deck profile.

The contribution of deck parallel to the beam is ignored.

C.5.2 FibreFlor

The contribution of the fibres to the longitudinal shear capacity when determining the Transverse Reinforcing is given by:

vr = 2.42 Acv

where Acv is the area of the concrete. When the deck is parallel to the beam, Acv only includes the area of concrete above the deck, but when the deck is perpendicular to the beam Acv includes the area within the deck rib. If the deck is parallel on one side of the beam and perpendicular on the other, the area of the concrete within the rib will be ignored when calculating the required transverse reinforcing for the side with deck parallel and will include the area of the concrete within the rib when calculating the required transverse reinforcing for the side with deck perpendicular.

The contribution of FibreFlor to vr is not combined with that of conventional reinforcement; if the FibreFlor is not sufficient alone, its contribution is ignored and conventional reinforcement is used, based on conventional design requirements.

When FibreFlor is used, the contribution of the concrete to vr is ignored but the contribution of the deck, vp, is included.

The contribution of deck parallel to the beam is ignored.

C.6 Beam Design Report

Format of reports for designs incorporating steel or synthetic fibers.

C.6.1 Dramix

The Beam Design Report has been modified to show the Dramix design results as follows:

```
COMPOSITE PROPERTIES (Not Shored):
.
.
.
Decking Type (with Dramix)       Kingspan MD 60
Kingspan MD 60
.
.
.
TRANSVERSE REINFORCING:
Dramix RC-65/60-BN Steel Fibres
fy (N/mm2):     900.0
dosage (kg/m3):     30.0
Reinforcement fy (N/mm2):     460.0
Total Longitudinal v (kN/m):   388.3
Left Side:
Longitudinal v (kN/m)=138.7
Dramix Steel Fibres (kN/m): 0.7 Asv fy=365.2
Concrete Resistance (kN/m): 0.03 eta Acv fcu=167.7
```

```
Maximum vr (kN/m): 0.8 eta Acv sqrt(fcu) + vp=748.7 + vp
.
.
.
Right Side:
Longitudinal v (kN/m)=138.7
Dramix Steel Fibres (kN/m): 0.7 Asv fy=365.2
Concrete Resistance (kN/m): 0.03 eta Acv fcu=167.7
Maximum vr (kN/m): 0.8 eta Acv sqrt(fcu) + vp=748.7 + vp
.
.
.
```

The value given in this report for Required Asv is based on the area required to resist the shear, after that shear has been reduced by the contribution of the Dramix steel fibres. Hence, Required Asv shows the traditional reinforcing required in addition to the Dramix steel fibres.

C.6.2 FibreFlor

The Gravity Beam Design Report has been modified to show the FibreFlor design results as follows:

```
COMPOSITE PROPERTIES (Not Shored):
.
.
.
Decking Type (with FibreFlor)     Corus ComFlor 51    Corus
ComFlor 51
.
.
.
TRANSVERSE REINFORCING:
FibreFlor
    dosage (kg/m3): Novocon FE 1050: 25, 30 and 35
Fibermesh: 0.90
Reinforcement fy (N/mm2):     460.0
Total Longitudinal v (kN/m):   388.3
Left Side:
Longitudinal v (kN/m)=136.4
FibreFlor (kN/m): 2.42 Acv=381.4
Concrete Resistance (kN/m): 0.03 eta Acv fcu=168.7
Maximum vr (kN/m): 0.8 eta Acv sqrt(fcu) + vp=753.2 + vp
.
.
.
Right Side:
Longitudinal v (kN/m)=136.4
FibreFlor (kN/m): 2.42 Acv=381.4
Concrete Resistance (kN/m): 0.03 eta Acv fcu=168.7
Maximum vr (kN/m): 0.8 eta Acv sqrt(fcu) + vp=753.2 + vp
.
```

```
.
.
```

Appendix D
Smartbeams

This appendix addresses with the technical information regarding the analysis and design of Smartbeams.

D.1 Technical Notes

Contains explanations of the assumptions and methodology used by RAM SBeam in the design of Smartbeams.

Much of the information given the Steel Beam Technical Notes section is applicable to the design of Smartbeams.

An outline of the procedure is given in the next several sections.

D.1.1 Compression Flange Bracing

For the calculation of unbraced length of beams and Smartbeams, both the top and bottom flanges are considered to be braced wherever another beam or Smartbeam frames in. For Smartbeams this is true regardless of the type of Smartbeam-to-beam connection designated in the Criteria - Smartbeams command. Note that this assumption is made even when Bearing connections are designated, which in reality do not brace the bottom flange. This assumption has no impact on the supporting beam if the beam has no negative moment (i.e., it is not in uplift), but may be unconservative when the supporting beam has a negative moment (i.e., it is in uplift, resulting in compression on the bottom flange).

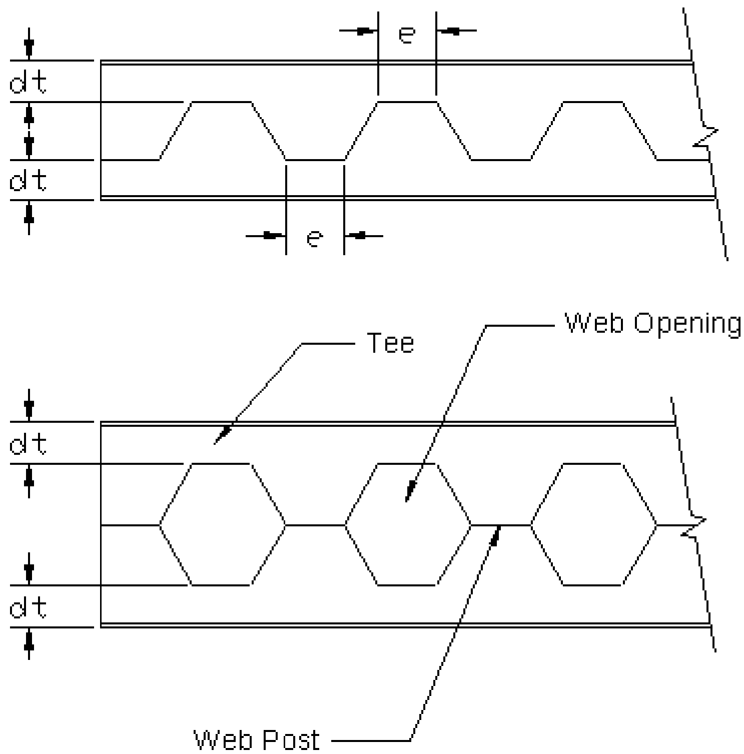
D.2 Nomenclature

Describes the nomenclature for Smartbeam openings and section designations.

D.2.1 Castellated Beam

The following figure shows a wide flange beam cut in a castellated pattern, and the resulting castellated Smartbeam.

Figure D-1: Castellated Smartbeam



e

Web post width and tee length.

b

Width of sloped portion.

dt

Depth of tee.

dg

Castellated beam depth.

> **Note:** For Castellated beams, the actual depth is a function of dt and the web hole size. The nominal depth is approximately the depth that results from using the standard dt. The actual depth is shown on the reports.

d

Depth of root beam.

ho

Height of hole.

wo

Width of hole.

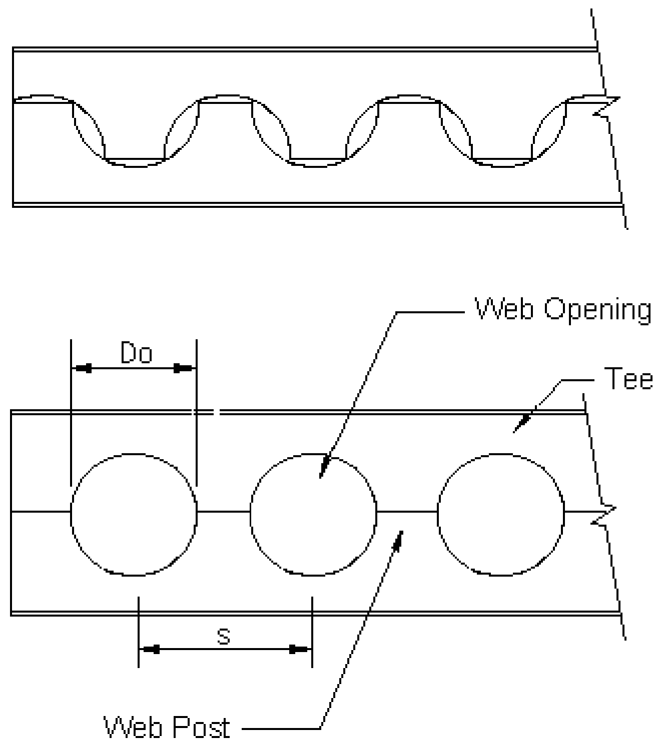
phi

Angle between flat and sloped portion of the hole.

D.2.2 Cellular Beam

The following figure shows a wide flange beam cut in a cellular pattern, and the resulting Cellular Smartbeam.

Figure D-2: Cellular Smartbeams



e

Web post width.

Do

Diameter of hole.

S

Center to center hole spacing

dg

Cellular beam depth.

> **Note:** For Cellular beams the actual depth is a function of the web hole diameter, Do, and the hole spacing, S, so the actual depth may vary from the nominal depth given.

D.2.3 Section Labels

Smartbeams use a labeling scheme similar to that used for standard sections. The label begins with "CB" for Castellated beams and "LB" for Cellular beams. The nominal depth is listed next,

followed by “x”, followed by the weight per foot of the beam, which is the same as the weight per foot of the standard beam from which the Smartbeam was manufactured.

D.2.4 Example

A CB18x14 has a nominal depth of 18” and weighs 14 lbs/ft. The top half and the bottom half are from the same beam size – in this case a W12x14.

A Smartbeam composed of two different sizes is referred to as an asymmetric section. For such sections the label lists the weight per foot of the beam used in the top half, followed by “/”, followed by the weight per foot of the beam used in the bottom half. For example, a CB18x14/16 has a nominal depth of 18”, and the top half is composed of a beam that weighs 14 lbs/ft (in this case a W12x14) and the bottom half is composed of a beam that weighs 16 lbs/ft (in this case a W12x16), resulting in a beam that weighs 15 lbs / ft (the average of the weights of the two standard beams).

D.3 Steel Design Codes for Smartbeams

The design of Smartbeams may be based on either AISC 360-05 ASD, AISC 360-05 LRFD, AISC ASD 9th ed. or AISC LRFD 3rd.

Specifically, the following codes have been implemented:

- “*Specification for Structural Steel Buildings - (March 9, 2005)*”, ANSI/AISC 360-05 ASD (Allowable Strength Design) and ANSI/AISC 360-05 LRFD (Load Resistance Factored Design) published by the American Institute of Steel Construction in Manual of Steel Construction (13th Edition).
- “*Specification for Structural Steel Buildings - Allowable Stress Design and Plastic Design (June 1, 1989)*”, published by the American Institute of Steel Construction in Manual of Steel Construction - Allowable Stress Design (9th Edition). The requirements of Supplement No. 1 (December 17, 2001) are also included as an option.
- “*Load and Resistance Factor Design Specification for Structural Steel Buildings (December 1, 1993)*”, published by the American Institute of Steel Construction in Manual of Steel Construction - Load and Resistance Factor Design (3rd Edition).

D.4 Castellated Beam Design Procedures

Methodology used for the design of castellated Smartbeams.

D.4.1 AISC 360-05 ASD Design Procedure (13th Edition)

Using AISC 360-05 ASD requirements for the calculation of factored forces and the calculation of section capacities, with some modification to account for the different nature of Castellated beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear Vu is calculated and compared with the shear capacity

Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and an omega of 1.5.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and an omega of 1.5.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear Vu through any web post and comparing it with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and an omega of 1.5. When the top piece is made from a different beam size than the bottom piece, the capacity is based on the thinner of the web thicknesses of the top and bottom pieces. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual factored forces on the most critical web post. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The bending capacity Mn is based on the gross cross section of the Castellated beam. The conditions of the limit states of Lateral Torsional Buckling, Flange Local Buckling, and Web Local Buckling are checked. The section is not allowed if the web is slender.

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee is calculated. The axial capacity Pn and the bending capacity Mn are based on the properties of the tee. The interaction of the axial force and bending moment with the corresponding capacities is then calculated.

D.4.2 AISC 360-05 LRFD Design Procedure (13th Edition)

Using AISC 360-05 LRFD requirements for the calculation of factored forces and the calculation of section capacities, with some modification to account for the different nature of Castellated beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and a phi of 1.0.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and a phi of 1.0.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear Vu through any web post and comparing it with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and a phi of 1.0. When the top piece is made from a different beam size than the bottom piece, the capacity is based on the thinner of the web thicknesses of the top and bottom pieces. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual factored forces on the most critical web post. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The bending capacity Mn is based on the gross cross section of the Castellated beam. The conditions of the limit states of Lateral Torsional Buckling, Flange Local Buckling, and Web Local Buckling are checked. The section is not allowed if the web is slender.

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee is calculated. The axial capacity Pn and the bending capacity Mn are based on the properties of the tee. The interaction of the axial force and bending moment with the corresponding capacities is then calculated.

D.4.3 ASD Design Procedure (9^{th} Edition)

Using ASD requirements for the calculation of allowable stresses, with some modification to account for the different nature of Castellated beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear stress fv is calculated and compared with the allowable shear stress Fv per Eq (F4-1) or (F4-2) based on the h/tw of the gross section.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear stress fv is calculated and compared with the allowable shear stress Fv per Eq (F4-1) or (F4-2) based on the h/tw of each tee individually.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear stress fv through any web post and comparing it with the allowable shear stress Fv which is given as 0.4Fy. The noncomposite beams and for the precomposite condition of composite beams the methodology is based on the third method given in Design of Welded Structures by Omer W. Blodgett, pp4.7-8 and 4.7-9. The composite condition is also checked. When the top piece is made from a different beam size than the bottom piece, the stress is based on the thinner of the web thicknesses of the top and bottom pieces.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual forces on the most critical web post.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The actual bending stress fb and the allowable bending stress Fb are based on the gross cross section of the Castellated beam. When the unbraced length is greater than Lc, Fb calculated per (F1-6) or (F1-7), and it is reduced by Qs to account for slenderness. The section is not allowed if h/tw > 760.0 / sqrt(Fb).

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee

is calculated, from which the actual axial stress fa and the actual bending stress fb are calculated. The allowable axial stress Fa and the allowable bending stress Fb are based on the properties of the tee. The interaction of the actual and allowable stresses is then calculated. The stresses on both the flange and the tip of the web are considered.

D.4.4 LRFD Design Procedure (3rd Edition)

Using LRFD requirements for the calculation of factored forces and the calculation of section capacities, with some modification to account for the different nature of Castellated beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (F2-1), (F2-2) or (F2-3) based on the h/tw of the gross section, and a phi of 0.9.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (F2-1), (F2-2) or (F2-3) based on the h/tw of each tee individually, and a phi of 0.9.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear Vu through any web post and comparing it with the shear capacity Vn per Eq (F2-1), (F2-2) or (F2-3) based on e/tw of the post, and a phi of 0.9. When the top piece is made from a different beam size than the bottom piece, the capacity is based on the thinner of the web thicknesses of the top and bottom pieces. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual factored forces on the most critical web post. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The bending capacity Mn is based on the gross cross section of the Castellated beam. The conditions of the limit states of Lateral Torsional Buckling, Flange Local Buckling, and Web Local Buckling are checked. The section is not allowed if the web is slender.

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee is calculated. The axial capacity Pn and the bending capacity Mn are based on the properties of the tee. The interaction of the axial force and bending moment with the corresponding capacities is then calculated.

D.4.5 Deflection

Methodology used in calculating the reported deflection of Smartbeams.

For the design of noncomposite beams, and of the precomposite condition of composite beams, the default methodology reduces the stiffness of the bare beam section by 10%. The option to use the Virtual Work Method based on Design of Castellated Beams for use with BS5950 and BS 449, Appendix 2 may also be selected in the Smartbeams dialog. For more information on deflection calculations based on reduced stiffness, contact CMC Steel Products directly.

For the design of composite beams, the deflections based on the effective section Ieff are calculated, where Ieff is calculated based on the net section. The resulting deflections are then multiplied by 1.10 to account for shear effects.

D.5 Cellular Beam Design Procedures

Methodology used for the design of cellular Smartbeams.

D.5.1 AISC 360-05 ASD Design Procedure (13th Edition)

Using AISC 360-05 ASD requirements for the calculation of factored forces and the calculation of section capacities, with some modification to account for the different nature of Cellular beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and an omega of 1.5.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and an omega of 1.5.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear Vu through any web post and comparing it with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and an omega of 1.5. When the top piece is made from a different beam size than the bottom piece, the capacity is based on the thinner of the web thicknesses of the top and bottom pieces. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual factored forces on the most critical web post. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The bending capacity Mn is based on the gross cross section of the Cellular beam. The conditions of the limit states of Lateral Torsional Buckling, Flange Local Buckling, and Web Local Buckling are checked. The section is not allowed if the web is slender.

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee is calculated. The axial capacity Pn and the bending capacity Mn are based on the properties of the tee. The interaction of the axial force and bending moment with the corresponding capacities is then calculated.

D.5.2 AISC 360-05 LRFD Design Procedure (13th Edition)

Using AISC 360-05 LRFD requirements for the calculation of factored forces and the calculation of section capacities, with some modification to account for the different nature of Cellular beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and a phi of 1.0.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and a phi of 1.0.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear Vu through any web post and comparing it with the shear capacity Vn per Eq (G2-1) and (G2-2) or (G2-3), (G2-4) or (G2-5) based on the h/tw of the gross section, and a phi of 1.0. When the top piece is made from a different beam size than the bottom piece, the capacity is based on the thinner of the web thicknesses of the top and bottom pieces. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual factored forces on the most critical web post. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The bending capacity Mn is based on the gross cross section of the Cellular beam. The conditions of the limit states of Lateral Torsional Buckling, Flange Local Buckling, and Web Local Buckling are checked. The section is not allowed if the web is slender.

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee is calculated. The axial capacity Pn and the bending capacity Mn are based on the properties of the tee. The interaction of the axial force and bending moment with the corresponding capacities is then calculated.

D.5.3 ASD Design Procedure (9th Edition)

Using ASD requirements for the calculation of allowable stresses, with some modification to account for the different nature of Cellular beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear stress fv is calculated and compared with the allowable shear stress Fv per Eq (F4-1) or (F4-2) based on the h/tw of the gross section.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear stress fv is calculated and compared with the allowable shear stress Fv per Eq (F4-1) or (F4-2) based on the h/tw of each tee individually.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear stress fv through any web post and comparing it with the allowable shear stress Fv. When the top piece is made from a different beam size than the bottom piece, the stress is based on the thinner of the web thicknesses of the top and bottom pieces. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual forces on the most critical web post. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The actual bending stress fb and the allowable bending stress Fb are based on the net cross section of the Cellular beam. When the unbraced length is greater than Lc, Fb is calculated per (F1-6) or (F1-7), and it is reduced by Qs to account for slenderness. The section is not allowed if h/tw > 760.0 / sqrt(Fb).

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee is calculated, from which the actual axial stress fa and the actual bending stress fb are calculated. The allowable axial stress Fa and the allowable bending stress Fb are based on the properties of the tee. The interaction of the actual and allowable stresses is then calculated. The stresses on both the flange and the tip of the web are considered.

D.5.4 LRFD Design Procedure (3rd Edition)

Using LRFD requirements for the calculation of factored forces and the calculation of section capacities, with some modification to account for the different nature of Cellular beams, the following design checks are performed.

Shear on Gross Section

This is done by calculating the maximum shear along the span (this is usually one end or the other) from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (F2-1), (F2-2) or (F2-3) based on the h/tw of the gross section, and a phi of 0.9.

Shear on Net Section

This is done by calculating the maximum shear at any hole and splitting the shear between the top and the bottom tees, from which the actual shear Vu is calculated and compared with the shear capacity Vn per Eq (F2-1), (F2-2) or (F2-3) based on the h/tw of each tee individually, and a phi of 0.9.

Horizontal Shear (through web post)

This is done by calculating the worst horizontal shear Vu through any web post and comparing it with the shear capacity Vn per Eq (F2-1), (F2-2) or (F2-3) based on the width/thickness ratio of the post, and a phi of 0.9. When the top piece is made from a different beam size than the bottom piece, the capacity is based on the thinner of the web thicknesses of the top and bottom pieces. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Web Post Buckling

This is done by calculating the capacity of the web post against a buckling failure, and comparing it to the actual factored forces on the most critical web post. This check is performed for both the precomposite and postcomposite conditions for composite beams.

Lateral Torsional Buckling / Unbraced Length

This check is done for Noncomposite Smartbeams only. It is not done for Composite Smartbeams since they are continuously braced by the deck, nor is it done for the precomposite condition. The bending capacity Mn is based on the net cross section of the Cellular beam. The conditions of the limit states of Lateral Torsional Buckling, Flange Local Buckling, and Web Local Buckling are checked. The section is not allowed if the web is slender.

Vierendeel Bending

This check examines the combined effects of the bending and axial forces on the top and bottom tees resulting from the shear and moments on the beam. The Vierendeel Bending check is performed on every tee, and is performed for both the precomposite section and the composite section for composite Smartbeams. The axial force and bending moment on the tee

is calculated. The axial capacity Pn and the bending capacity Mn are based on the properties of the tee. The interaction of the axial force and bending moment with the corresponding capacities is then calculated.

D.5.5 Deflection

Methodology used in calculating the reported deflection of Smartbeams.

For the design of noncomposite beams, and of the precomposite condition of composite beams, the default methodology reduces the stiffness of the bare beam section by 10%. The option to use the Virtual Work Method based on Design of Composite and Noncomposite Cellular Beams, Section 6.3.1, published by The Steel Construction Institute may also be selected in the Smartbeams dialog. For more information on deflection calculations based on reduced stiffness, contact CMC Steel Products directly.

For the design of composite beams the deflections based on the effective section Ieff are calculated, where Ieff is calculated based on the net section. The resulting deflections are then multiplied by 1.10 to account for shear effects.

D.6 Contact

For more information on the design of Smartbeams, contact CMC Steel Products directly.

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